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THE DESIGN OF GENERATORS FOR ELECTRIC POWER TRANSMISSION WORK.

By David B. Rushmore,* M. Am. Inst. E. E.

The generator is one of the important elements of a transmission system. It is the primal source of the electrical energy, and upon its operation and characteristics depends the successful working of the system of which it is a part. The voltage regulation of the system is largely dependent on that of the generator. In the consideration of efficiency, cost, and reliability of the system, it is one of the elements which, with the prime mover, transformers, switchboards, line, receiving stations and circuits, constitute the system. In considering the various questions which are of interest in connection with present methods and problems of electrical transmission of energy, it is suitable that we pay proper attention to the alternator. With the object of bringing before those not directly concerned with the designing and manufacturing of electrical machinery, a few of the characteristics and relations of this machine, which so many are called upon to specify and to operate, the present is written. Naturally, much of what follows will be applicable to alternators in general, not merely to those used in high-voltage transmission systems.

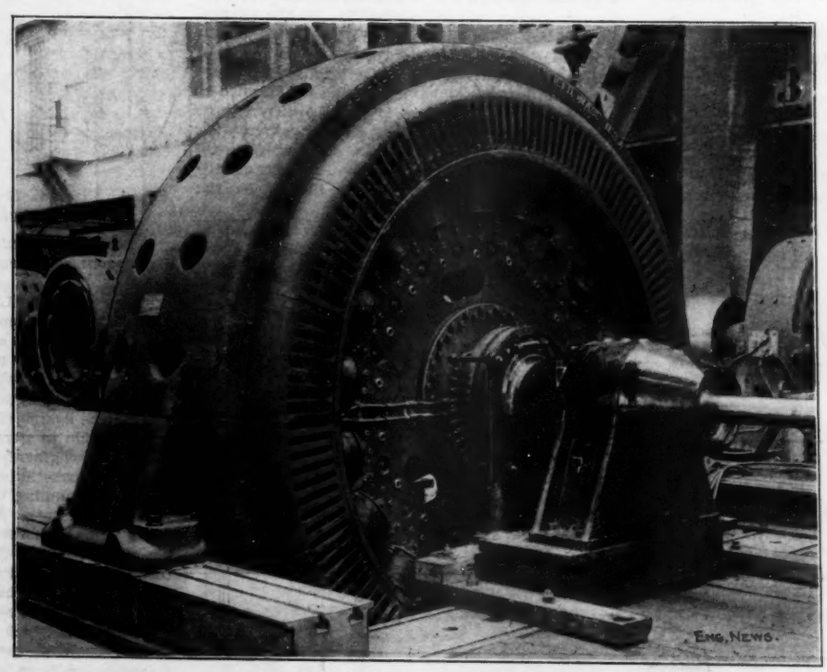
PECULIARITIES OF TRANSMISSION WORK.

There are certain peculiarities of high voltage power transmission which differentiate, to some extent, the requirements which a generator must fulfill from those in other kinds of work. The voltage of the line and sometimes of the generator is high. The power house is often located in some distant mountain locality, which is difficult of access. The machinery must be hauled many miles over newly made roads, and must often be especially designed therefor. Mountain valleys, especially in the neighborhood of streams are very damp places, and as no artificial heat is in the power houses, the machines may be subjected to moisture. The long lines, in some cases between one and two hundred miles (214 is the longest), and double lines at that, offer a great many opportunities for trouble, so that grounds and short circuits are of frequent occurrence, and the number of severe strains on the apparatus is large. Most transmission plants are utilizations of water-powers, which give somewhat different conditions from engine driving. Some systems have a considerable proportion of the output utilized by induction and synchronous motors in large units; when induction motors are used for mine hoists, or when synchronous motors are started by being thrown on the line, the disturbance produced in the entire current-carrying system requires careful attention if the system is to be satisfactory for lighting purposes at the same time. Transmission lines are also much affected by lighting discharges and other atmospheric disturbances which become more frequent as the length of line is increased. Storms are of greater violence in mountainous countries.

Waterwheels are likely to have a certain amount of vibration when the heads of water range from 700 to 1,500 ft. They run at high speeds, even when the units are as large as several thousand kilowatts; this necessitates few poles and concentrated reactions, also very high peripheral speeds and mechanical stresses, which, however, are not unmixed evils in the matters of first cost and heating. Static capacity and charging currents which are insignificant at 10,000 volts and ten miles, rise to be of great importance when we reach 150 miles and 60,000 volts. Small irregularities in wave form, the factor of safety of the insulation, the ability to run one unit alone on the line, all of these questions are much changed at the latter figures.

The atmosphere of mountains is conducive to a spirit of freedom, even in regard to shooting off insulators and throwing wires over the line. This, together with large birds, storms of sand, salt and alkaline earths, land slides, etc., adds to the elements which cause frequent interruptions of service and throw unusual strains upon generators and other apparatus.

The growth of modern engineering practice is always toward greater refinement. The special adaptation of machinery to the conditions of operation becomes of increasing importance. For transmission work the conditions are severe and the generator must be rugged in character as well as possessing the electrical properties suitable to the particular work in view.



AN ALTERNATOR FOR LONG-DISTANCE TRANSMISSION WORK.
Built for the Valley Counties Power Co. of California by the Stanley Electric Mfg. Co., Pittsfield, Mass.
Capacity, 4,000 KW. Speed, 400 r. p. m. Voltage, 2,400 volts. Current, 60 cycles, three-phase. Direct-connected to a Doble Impulse water-wheel.

INSULATION.

The principal demands upon generator insulation for transmission work are that it shall be moisture proof; that it shall possess a high factor of safety; that the vibration of the unit shall not injure it. It is desirable that the ohmic (leakage) resistance be high as well as its static (disruptive) strength and that it have low specific inductive capacity as well as small dielectric hysteresis loss. The materials at present used for armature insulation are various kinds of pressboards, both dry and treated; silk, linen and cotton cloths usually containing thick oils; mica and micanite; wood and fiber; and a large variety of varnishes and japans. Insulating materials must possess dielectric strength and some must also be mechanically strong. They differ largely in the extent to which they are affected by continued heating, by the dielectric hysteresis and the small but unavoidable leakage current, by the constant vibration, and by sudden and severe shocks or blows to which the machine is subjected on bad short-circuits.

In situations where the temperature changes are great and sudden and where the machines are all occasionally out of service for some time due to accidental interruptions to the line, it is of very great importance that all insulation be perfectly non-absorbent. The short-circuit drying-out of the

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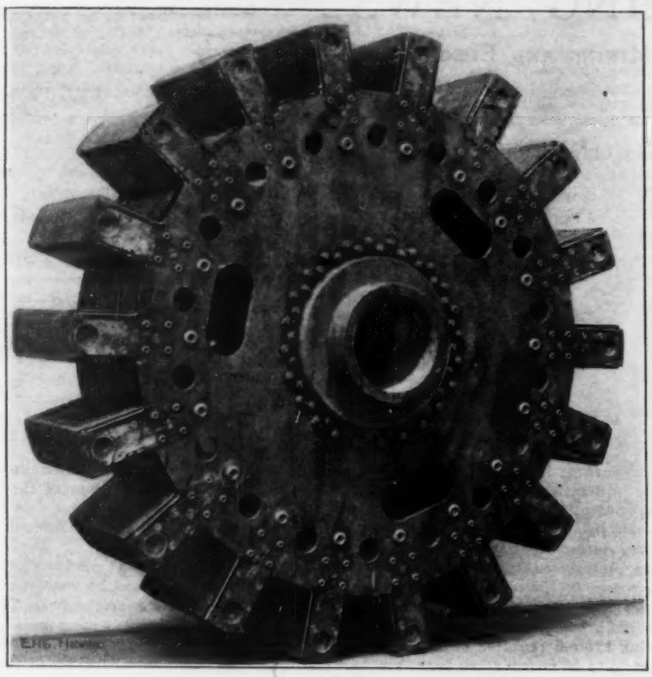


FIG. 2. VIEW OF STEEL-CENTER FIELD CORE ASSEMBLED.

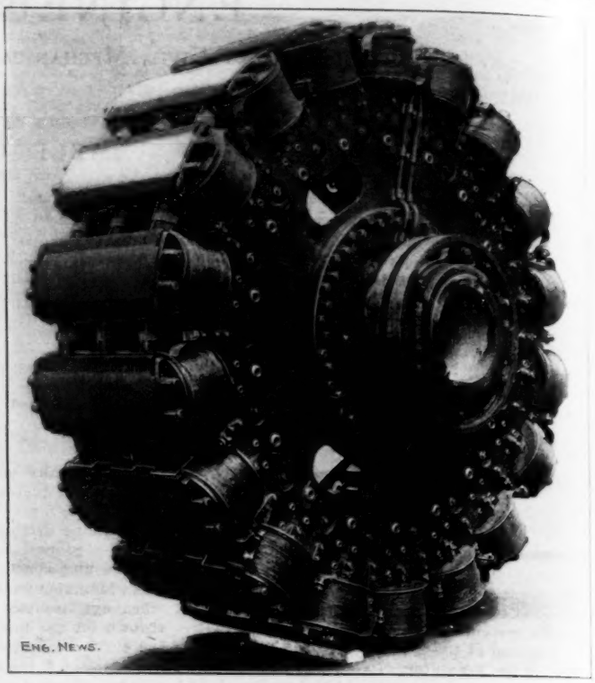


FIG. 3. VIEW OF WOUND FIELD.

machine when first started is not possible afterwards under running conditions.

Ability to withstand static stress is not necessarily a measure of the goodness of the insulation, upon the durability of which the life of the machine depends.

It would appear fom recent discussions in foreign societies that it is still the practice in some countries to mill out the slots of alternator armatures. The effect of the heating of this iron adjacent to the armature insulation must be very injurious to the latter. In America, however, punched slots requiring no tool-finishing are universal.

The frames of high voltage generators or those used on transmission lines are now almost universally grounded. The danger to attendants is thus somewhat lessened, but the strain on the armature insulation is greater.

Static discharges produce ozone and conductor insulation must not be affected thereby.

TYPE OF CONNECTION.

The question as to which type of connection is better, delta or star, is important. The reasons which apply for and against each type of connection for transformers apply with equal force to the generator. One point of especial interest which does not appear to be generally known is the effect of a delta connection in a system having a pronounced third or ninth harmonic. Capacity in the system tends to amplify, in the current curve, any harmonics which may exist in the original c. m. f. wave. Now in an armature or transformers having a delta connection, the third harmonic instead of having a phase difference of 120° in the different legs is directly in phase, as shown in Fig. 4, and tends to send a circulating current around the delta. In one experimental alternator the current around the delta was of full-load value. As this current is limited by the resistance and inductance of the generator, and not by the "synchronous impedance," it is less in machines of high inductance. Modern generators are built with wave forms which follow so closely the sine law that this fact is perhaps more of theoretical than of practical interest; yet it should be borne in mind as a possible explanation of phenomena occasionally found in practice.

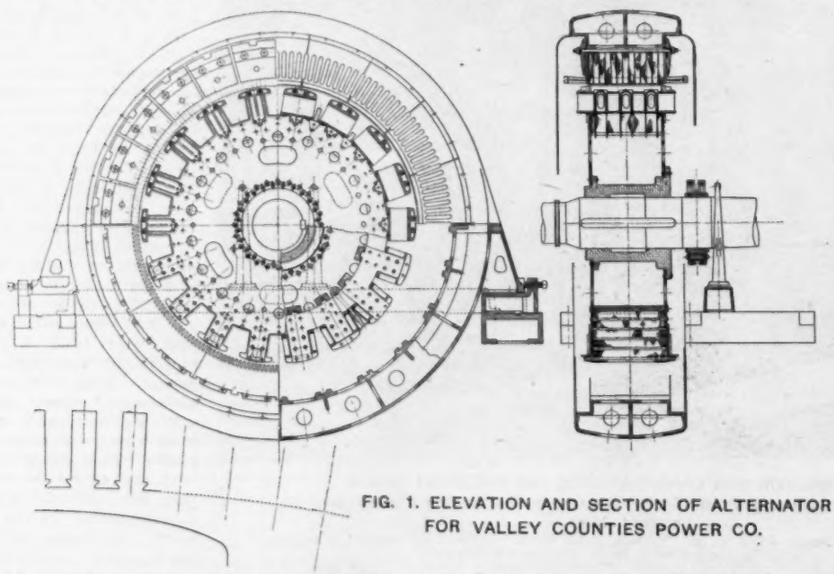


FIG. 1. ELEVATION AND SECTION OF ALTERNATOR FOR VALLEY COUNTIES POWER CO.

A small amount of static capacity is desirable in a generator; it should be less with a star than with a delta armature connection, owing to the fewer turns on the armature.

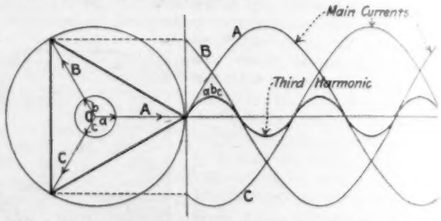


Fig. 4. Diagram Showing How Delta-Connection Intensifies Third and Ninth Harmonics.

A bad short-circuit may burn out two-thirds of a star-connected armature, and but one-third of a delta.

PARALLEL RUNNING.

Alternators driven by water-wheels are usually free from troubles of parallel operation, and yet the reason is often misunderstood. True, there is almost a total absence of disturbing causes; but while variation in angular velocity is usually considered the source of evil, it may have little to do with trouble in parallel running. But the lower speeds of engine-driven alternators are accompanied by constants which are more unfavorable to parallel running then those obtaining in water-wheel alternators. As a result, the many interesting relations between the natural mechanical and electrical periods, the fly wheel effect, damping torque, mechanical resonance, generator regulation, etc., are of but theoretical interest to the operator of water-power stations. Indeed, on some systems which have plants in different parts of the country, generators separated by long transmission lines are operated in parallel with perfect success. An equal division of load is obtained by water-wheel governors. In this respect close regulation of generators is not desirable beyond a certain point. The amount of flywheel effect desired also depends upon the quality of the governor. For other reasons than for parallel running it is sometimes desirable to have a certain amount of flywheel capacity to give inertia, the same as one wishes self-induction (or electrical inertia) in the armature circuit.

GENERAL GENERATOR CHARACTERISTICS.

A piece of machinery, subject to all possible variations in characteristics, the alternating cur-

ent generator needs to be fitted to its particular work with the same care that is taken by nature in establishing harmony with environment. The points of note in connection with an alternator are type, output, speed, frequency, voltage, number of phases, voltage-regulation, efficiency, heating, overload capacity, insulation strength, and weight.

TYPE.—For different types we have the inductor alternator, the revolving field type, with either internal or external fields, and the revolving armature type. Many others might be mentioned as a matter of technical interest, but these are the ones of commercial importance to-day.

The inductor alternator possesses maximum simplicity, has no moving wire, and has high efficiency at light loads as well as at full load; the power necessary for field excitation is small, due to the single field-coil; the regulation can be made anything desired; the armature coils can be easily removed. The mechanical construction is rugged and especially that of the moving part. There is no wear on any part except the bearings. The natural ventilation is excellent at the higher speeds. The field-coil, because of its low self-induction, cannot be punctured by a sudden breaking of the field circuit. With the same non-inductive regulation, the regulation at various power factors is at least as good as in other types. With the same regulation, more of the drop is due to inductance and less to reaction, so that on short circuit the instantaneous rush of current is less and not so much harm is done to apparatus and system involved. The wave-form at no load is a sine curve and any slight distortion under load is entirely within the hands of the designer. The inductor alternator has been very largely used for transmission work on the Pacific Coast.

The revolving field type has an external stationary armature and in most cases has a distributed winding. The first Niagara machines are the only ones of prominence which have been built in this country having an external field. The last ones ordered as well as those for the Canadian power house, have internal fields, which is common practice for machines of this type. The field-coils of edgewound strip copper are practically indestructible by heat. The drop in voltage, due more to armature reaction than to self induction, can be made large or small. By properly shaping the pole the curve of voltage can be made a sine wave. If desired, the saturation curve may be made nearly straight. By some degree of refinement in designing, it is claimed, the different parts of the magnetic circuit may reach saturation at the same time and the magnetization curve given a sharp bend, so that the machine may have good regulation in conjunction with a small short-circuit current.

OUTPUT.—The first alternators used were of but a few hundred kilowatts capacity. Many plants have been installed having units between 500 KW. and 1,000 KW. From here rapid jumps were made to 2,000 KW., to 3,500, to 5,000, and now we have the new generators for the Canadian power-house at Niagara Falls, of 7,500 KW. each, the largest in the world.

VOLTAGE-REGULATION.—It is especially with regard to regulation that generators should be suited to the lines and conditions of service.

Good regulation is desirable for the following reasons: The regulation of the system as a whole, one of its chief characteristics, will be better. The voltage will not rise to so great a value on sudden opening of receiver circuit. Less careful attendance is necessary, as the change in exciting power for variation in load and power factor is less. Induction and synchronous motors may be thrown on the line with less disturbance.

Bad regulation of the generators in a transmission system produces: Abnormal variation in excitation, and bad regulation of the whole system and need for constant watchfulness; excessive rise of voltage due to charging current; ability to run machine on short circuit momentarily without injury; difficulty in regulating for unbalanced loads; disastrous effects from sudden inductive loads.

It is possible to predetermine very closely the regulation of generators, transformers and line, so that the results to be had in any case are a matter of choice and specification. In most instances, a fair regulation, from 6 to 10% on non-inductive loads (i.e. loads of 100% power-factor) will be found satisfactory. The character of the load; the question of whether the system is to do much lighting; the number, size and power-factor of motors which may be suddenly thrown on the line; the capacity and charging current of the line; the number and length of lines from the same station; the safety devices and switches; are some of the factors which should be considered in deciding upon the best regulation. Good regulation (i.e. small variation in voltage between no-load and full-load) means large ratio of copper on field to that on armature, or else large ratio of iron to copper in total machine, both tending toward greater cost. In some transmission plants machines are used both as generators and as motors, the function varying with the time of day or year. This holds true of both synchronous and induction machines. The alternators of the Standard and Bay Counties lines of California have a regulation of about 4% on non-inductive loads. The power-factor on long lines at the generators is often over 92% and in operation the current varies from lagging to leading.

The regulation of an alternator is an important characteristic of its operation and the principal factor in its design. Very different values are demanded by different classes of service. Alternators supplying welding machines must have the best possible regulation. Those connected to short transmission lines without safety devices should have a safe value of short circuit current, i. e., they should have bad regulation, since good regulation implies a large current on short circuit and vice versa. Good regulation may be obtained by small reactions, by saturated magnetic circuits or by relatively large exciting magneto-motive forces. The relations between inherent regulation, form of saturation curve, percentage increase in excitation for different power factor loads, etc., may require choice in particular cases. Regulation depends upon armature reaction, self-induction, ohmic resistance, and the equivalent resistance of foucault currents. It is now predetermined with accuracy and can be obtained quite closely in the case of completed machines by means of a few simple tests.

A large number of methods for compounding alternators for constant voltage have been tried. Some of these have been fairly successful. The conditions of operation in transmission work necessitate, however, that some regulation be effected at the receiver station. A good regulator is desirable and may do much towards maintaining the proper voltage, even if a multiplicity of lines and power factors with unbalanced loads leave something to hand regulation.

Occasion is here taken to call attention to a point in theory in which an error may have been made by some writers. It has been considered by many that, when the iron is saturated in either the armature teeth or the pole corners, the cross or distorting ampere turns weaken the field by being unable to increase the flux as much in the strengthened pole corner as it is decreased in the weakened pole corner. So far as is known to the author, every writer, with the exception of Mr. C. C. Hawkins, has adopted this view and a number of theories and diagrams for predetermining alternator regulation have been based upon it.

No experimental proof has been shown to uphold it, but, on the contrary, much that exists points the other way. Brush lead in a continuous current dynamo and power factor in an alternator are in very close correspondence. In tests which have been made by field exploration of continuous current generators and by speed tests on separately excited motors, in both cases with local saturation and with the brushes at the neutral, the evidence, while not conclusive, points to the fact that the field is not weakened by armature reaction under that condition. In an alternator, with current in phase with the no-load voltage (which could be obtained with a leading terminal current) the drop in the armature should be due only to true armature self induction and resistance, except for minor causes as variation in power factor of field. That is to say, with non-inductive load in the armature of an alternator or with brushes at the neutral points in the continuous current generator, the cross field formed by the distorting ampere turns of the armature represents pure armature self-induction and is not interlinked with the exciting turns. The number of magnetic lines added on one side of the pole must exactly equal those subtracted on the other. Owing to the different densities, in both air and iron, the magneto-motive forces, and not the fluxes, are unequal on the two sides.

SIZE OF UNITS.—The size of the units should be such that there should preferably be never less than three nor more than ten. Exceptions in both directions can be found. At least one transmission plant is running with but a single unit, while that of the Michigan Lake Superior Power Co. is planned for eighty machines. The total output to be developed, the head of water and its relation to the prime mover, must be the determining factors.

SPEED.—The speed of the generator is usually determined by that of the wheels, which is in turn fixed by the head of water and the power of the unit. The limit of speed in the design of alternators has not been reached in the water-wheel type. In comparing machines, not only the output but also the speed should be considered, for after a certain size is reached the output of a given frame is proportional to the speed; kilowatts per revolution is a fair basis for comparison.

In studying the difficulties of electrical design, except where design is limited by peripheral velocities, the kilowatts per pole will be found to be the cause of concentrated reactions; this depends not only on speed but also on frequency. On this account it would be desirable to increase the frequency with speed and with output.

The largest generators in purely long-distance transmission work will be the 4,000 KW. alternators of the Valley Counties Company of California.

FREQUENCY.—The frequencies used at present in America are 66, 60, 50, 40, 33, 30 and 25 cycles per second; abroad, 50 and 100 cycles are customary. A few installations run at about 15 cycles. It would seem as if we were still some distance from standards. However, 60 cycles is used for most transmission work except where the employment of rotary converters makes 25 cycles desirable. The Standard and Bay Counties systems in California both operate at 60 cycles. The proper frequency is susceptible of fairly definite determination when the power, voltage, distance and means of utilization of energy are known.

VOLTAGE.—The voltage for which generators should be wound depends upon their output. Some of those for the early installations were wound for about 500 volts, although 2,400 volts soon became standard. It is expensive to wind small machines for high voltage, and the omission of step-up transformers is admissible only up to 15 000 volts—a low potential in these days. Alternators cannot practicably be built for higher voltages, so that step-up transformers become necessary.

NUMBER OF PHASES.—Except where existing single-phase or two-phase systems necessitate clinging to the old type, generators are now universally wound for three phase and all transmission plants are thus run.

WAVE-FORM.—The wave-form of the generator should be a sine curve, and the amplitude of any harmonic should not exceed from 3 to 5 per cent. of the fundamental. The various pieces of apparatus through which the energy passes, and the capacity of line, transformers, and armature will all tend to cause distortion. In order to illustrate the variation which may be found on actual machines, some curves are shown in Fig. 5, illustrating an experimental pole shape, the effect of slots, and the normal curve of an inductor alternator.

OVERLOAD CAPACITY.—The conditions of transmission have one distinguishing feature. The company owning the transmission plant and line is very seldom the user of the power. It is, then, to a greater degree than elsewhere, necessary for commercial reasons, to continue operating under any possible condition and even to suffer considerable damage to apparatus rather than have a serious shut-down. Thus in a system where a number of plants are tied together in a network, it not unfrequently happens that one plant must

carry its neighbor's load for a considerable period of time. So, while standard guarantees regarding loads and temperatures may have been made, it is very desirable that there be a considerable margin of safety, under any condition of operation, below the point of danger to insulation.

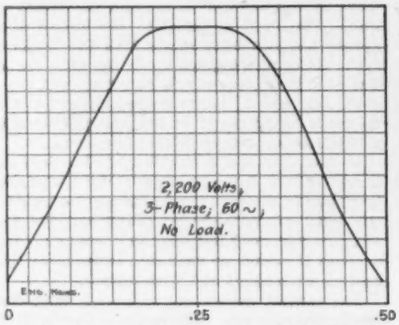
Differences in design and in quality of material used for insulation, to a considerable extent, affect the rise of temperature at overloads and also the injury which will result therefrom. The ratio of armature copper loss to iron loss and minor details regarding concentration of heat generation and of increase of fixed losses under load, may make a great difference in the operation at overloads of machines with the same characteristics at normal rating.

A MODERN TRANSMISSION ALTERNATOR DRIVEN BY WATER-WHEEL.

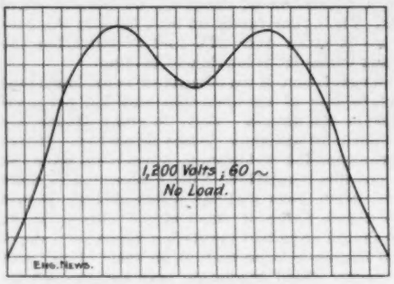
The preceding remarks may be supplemented by a description of an actual transmission generator, built for Pacific Coast work. The machine is somewhat special in several features, due to the special conditions of the problem, which state of affairs is not rare in transmission work, as already remarked. This generator was built by the Stanley Electric Mfg. Co. of Pittsfield, Mass., for the Valley Counties Power Co., one of the constituent companies of the California Gas and Electric Corporation. It is illustrated in the view on the first page of this issue and Figs. 1. to 3. The machine is for 4,000 KW., 400 r. p. m., 2,400 volts, three-phase current, 60 cycles, and has 18 poles. It is of the external-armature revolving-field type and is direct connected to a Doble water-wheel.

To thoroughly appreciate the difficulties of transportation in a mountainous country possessing nothing which can be called a road, one must have seen something of the actual work of hauling heavy machinery with fifty or more horse-power on the hoof. This particular machine was to be located in a place difficult of access, and was designed with special attention to the weight of single parts. Further, it was requisite that the machine should be tested at the works before shipment.

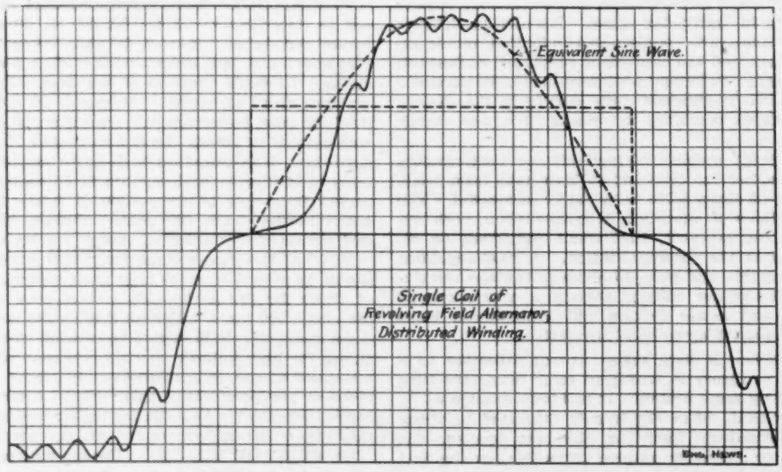
The alternator is mounted on two bearings and the water-wheel is mounted on the same shaft and overhangs one of the bearings; the high speed of the alternator together with its large output and manner of mounting necessitated that the revolving part should be as light as possible. Water-wheels operate at a speed which gives the rim a peripheral velocity equal to one-half the spouting velocity of the water. It is then possible that a sudden opening of the circuit, together with a sluggish action (or a failure to act) on the part of the governor, may increase the speed nearly 100 per cent., and the parts must be mechanically strong under this condition. Probably the most severe strain which comes on such a machine, and one which may come frequently in transmission work, is a bad short-circuit which in three or four seconds will change from the circuit conditions normal full-load running to complete rest. The



A.—Normal Voltage-Wave of Inductor Alternator.



B.—Voltage-Wave of Inductor Alternator Fitted with Special Pole-pieces, Showing Large Fifth Harmonic.



C.—Voltage-Wave of Revolving-Field Alternator, Showing Effect of Teeth of Armature-Core.

FIG. 5. TYPICAL CURVES OF FORM OF VOLTAGE-WAVES.

centrifugal forces in this type of machine limit the design, which explains the novel construction of the revolving part. The difficulty of transportation of total revolving element, together with the undesirability of forcing the hub on the shaft at the power house was the reason for the peculiar plate construction adopted.

As shown in the drawing, Fig. 1 (p. 368), the stationary armature is supported by an outside cast-iron shell which rests on two feet and is divided horizontally. The casing is well opened between its inside and the active laminations, and is well cored on the ribs and back, allowing free passage of air. Sections running parallel to the shaft are dovetailed and support the armature laminations. Sectional retainers support the ends of the active iron and are drawn together by bolts passing behind the core. Ventilating spaces are placed at each end and at frequent intervals throughout the length of the core. The ventilation and consequently the heat radiating properties are excellent at the high peripheral speeds.

Where (as in this machine) the amperes per conductor are high, it becomes necessary, in order to prevent foucault losses, to divide the armature conductors; a rectangular stranded cable was therefore used. By means of a vacuum process the interstices of this cable are completely filled with an insulating japan. By this treatment the cable is better able to conduct the heat from its middle portion to the outside radiating surface. Wooden wedges are used to hold the coils in the slot. In order to avoid the cross connections between the several groups if otherwise connected a wave winding is used, and for the reasons previously gives, the armature connection is star instead of delta. With twelve slots per pole, however, the E. M. F. would naturally be very close to a sine wave. In this case also the field poles so shaped, as has been customary practice with inductor alternators, that the distribution of flux at the pole face follows the sine law and would give a sine wave with a unicoil winding. (See detail sketch in Fig. 1.) This insures that in all cases the wave of electro-motive force generated under all possible conditions of load will be a sine curve.

Short circuits have a tendency to cause a spreading apart of the cross connections on the end of the armature winding, and to prevent this they are held together by clamping rings which also support the slightly flexible conductor cable. The ends of the armature coils are protected as well as hidden from view by sectional ventilated shields fastened to the cast-iron shell.

While the construction of the stationary armature represents to some extent a more or less standard type, that of the revolving field contains many elements of novelty. The high peripheral speed and the allowance for increase made the problem of securing the poles a serious one and necessitated abandoning the usual construction of a solid steel rim with poles bolted to it. The rim of the revolving part is built up of laminated iron ⅛ in. thick, one section of which includes two entire poles and the part between them. As the laminations from the poles lap in each direction, they leave between the poles sections consisting of laminations alternating with air spaces in equal part, through which, at the peripheral speed of over 11,000 ft. per minute, air will pass and thus cool in the best manner possible the field coils and armature surface. The laminations are dovetailed into steel pieces which run lengthwise with the shaft and which are riveted into the end plates. The whole mass of laminations is solidly riveted together by rivets which pass entirely through the section and through the end plates. Each piece of laminated iron in the field ring is a section comprising two poles and has the parts forming the two poles of unequal length (see Fig. 2). One pole extends out to the air gap while the other extends only to the top of the field coil. The top of the part extending to the air gap contains two holes. These laminations alternate in the width of any one pole, and thereby form a pole-end furrowed with deep slots. Inserted into these openings are pole tips which project over the field coil to hold it in place and to form the pole shoe; the latter, in the part which extends beyond the pole core, is like the ring of the field yoke; i. e., only half iron, the laminations alternating with equal air spaces. (See Fig. 3.) These tips are made of slightly thinner iron than that in the body of the core, and have a very small clearance at the bottom. Iron rods run through the holes in the tips and in the tops of the pole laminations, in a most secure manner holding that part of the field coil in place. The end of the coil is considered as if entirely separated from the main body and is held in place by a hollow phosphor bronze retainer which has an extension fitting into a hole countersunk into the end plate.

As the sides of the coil are parallel, and not truly radial, there is a component of the centrifugal force tending to make them bulge, and to prevent this, three wedges are placed between the long part of the coils and are held in place by straps passing over a saddle on them and down between the laminations of the field ring below which a rod is run through a hole in their ends, as is well shown in Fig. 3.

The field coil is of strip copper wound on edge.

the individual turns being separated from each other by thin varnished paper.

As an alternative construction the active part of the revolving member could have been mounted upon a cast steel spider, since the revolving mass of laminations is perfectly self-containing and will itself take up any centrifugal force, thereby entirely relieving the arms from any such strain except that caused by their own weight. The location of this plant can, however, be reached only with great difficulty and all machinery must be hauled a considerable distance. Objection was made to pressing the hub on the shaft at the power house, and although possible, it was very undesirable to attempt to haul the revolving part of the machine, together with the shaft, over the rough roads. In order to allow the hub to be pressed on the shaft before shipping and to keep the separate parts below an objectional weight, the plate construction as shown was adopted.

The laminated part is held securely between two heavy rolled steel plates. The rivets which pass through the laminations as well as the steel dovetailed pieces also, pass through these plates and are riveted on the outside. A steel hub is pressed on the shaft and the plates riveted to it. A difference in the diameters allows the hub to be inserted from one end; Fig. 1 shows the arrangement of hub and plates. The shaft for this machine is made hollow and is supported in two bearings each 16 × 60 ins. The problem of high-speed bearings is worthy of separate treatment.

Holes are cut in the plates to allow the admission of air for ventilation and for use in construction. Two rows of rivets, staggered with respect to each other, are used for each end.

The collector rings for the field exciting current are of cast-iron and are mounted on a separate sleeve on the shaft. The leads joining the field coils are made of special metal which will not be crystallized by vibration and are securely held against centrifugal force by supports extending outwardly at the end of the coils.

THE ORGANIZATION OF THE WOOD PRESERVERS' ASSOCIATION.

A convention was held this month at St. Louis, Mo., for the organization of a society to be devoted to the interests of those engaged in wood preservation. The movement originated with Messrs. J. D. Baker of Carbondale, Ill., and C. W. Berry, of Laramie, Wyo. Correspondence was conducted with a considerable number of the operating officials of wood preservation plants, and as a result about 35 of those interested met in the Transportation Building at the St. Louis Exposition on Monday, Oct. 10. Mr. Baker called the meeting to order and explained the purposes of those who issued the call, and a temporary organization was effected by electing Mr. Octave Chanute, of Chicago, as chairman of the meeting, and Mr. F. A. Kummer, of New York, as Secretary. A committee was also appointed to report a plan for a permanent organization consisting of Messrs. Baker and Berry, F. D. Beal (So. Pac. Ry., Oakland, Cal.), A. Nester, Perth Amboy, N. J., and C. B. Lowry, General Manager of the Columbia Creosoting Co. Announcement was made that Dr. Von Schrenk, of the Bureau of Forestry, in charge of the Government timber preservation plant on the Exposition grounds, had offered to make at this plant any tests desired by any member of the Association. The session then adjourned until 10 a. m. on the following day.

When the members reconvened on Tuesday, the report of the committee appointed on the previous day was presented and discussed section by section, and finally adopted as follows:

(1) A permanent organization shall be effected of a society to be known as the Wood Preservers' Association.
(2) All executive and administrative officers of plants actually carrying on wood preservation processes shall be eligible to membership.
(3) The officers shall be a President, three Vice-Presidents and a Secretary-Treasurer; these five to act as an Executive Committee to have full charge of the affairs of the association.
(4) The annual dues shall be $10 per annum, payable in advance.
(5) Meetings shall be held annually, the place of meeting to be selected at the previous meeting.
(6) Committees shall be appointed by the President to recommend standard methods of making chemical analyses of materials used in wood preservation.

The meeting then proceeded to the election of officers and the office of President was tendered to Mr. Octave Chanute of Chicago. Mr. Chanute explained that absence from the country in the near future would prevent his performing the duties of the office, and Mr. J. D. Baker was then elected President, Messrs. C. B. Lowry, H. J. Whitmore and F. A. Kummer, Vice-Presidents, and Mr. C. W. Berry, Secretary-Treasurer. Adjournment was then taken until 3 p. m.

At the afternoon session it was voted that a committee be appointed to draft a constitution and by-laws for the Association, and Messrs. Kummer, Faulkner and Walker were the committee selected. The President also appointed as a committee to prepare a standard method of chemical analysis for dead oil of coal tar, Messrs. Chas. Chanute, C. B. Lowry, and P. F. Dundon. As a committee on the analysis of chloride of zinc, he appointed Messrs. Angiers, Powers and Berry.

On motion it was voted that these committees should consult with manufacturers and their chemists before drafting specifications, and that as soon as their proposed standards were ready, copies should be mailed to each member with a request to send by mail his vote for approval or disapproval to the secretary.

The committee on drafting a constitution was also instructed to make provision for the connection with the association as Associate Members of those interested in timber preservation otherwise than as officers of timber preserving plants; such Associate Members to pay the same dues and have the same privileges as other members, except the right to vote.

After considerable discussion it was voted that another meeting of the Association shall be held in January next in New Orleans, the exact time and place to be fixed by the Executive Committee. A committee consisting of Messrs. Whitmore, Armstrong and Rollins, was appointed to prepare a programme and arrange for papers and topics of discussion to be presented at that meeting. Among the subjects suggested was that of a standard unit of measurement for quoting prices on timber preservation work. Adjournment was then taken.

PROTECTING LOW OVERHEAD STRUCTURES FROM GASES AND BLASTS OF LOCOMOTIVES.*

(1) We have a tunnel under a hotel where the hotel is supported by box girders, and the under side of these girders was covered with expanded metal and two coats of cement plaster. We have had no trouble with the cement, but we have had trouble with the expanded metal rusting off and the whole thing falling down. When originally built this was put on with plenty of time for it to set before any engine passed under it. The original coating has all fallen off, and we had it put on again one year ago, but it has nearly all come off the second time. We have something like 70 regular trains which pass under this structure working steam. This structure is only about 250 ft. from where the trains stop at a station, and these trains are long, heavy trains, working pretty hard. More or less moisture gets into this from somewhere, and affects the expanded metal. I have about made up my mind that the best thing in a new structure is to provide metal enough to stand the wear of the blast, and put on paint that will take care of the gases by applying often enough so that the gases will not get at the iron. I have had better success with graphite paint for this kind of work than any other. There is no danger of the iron rusting out where you sand-blast it off 70 times a day, as in this case. The structure is about 15 ft. above the top of the rails.—Grosvenor Aldrich; N. Y., N. H. & H. Ry.

(2) Concrete is the best material to be used for protection of any style of metal overhead bridge. The concrete to be made of Portland cement, and an aggregate not exceeding pea size. It must be applied in some way so that it will be homogeneous and continuous throughout. Expanded metal under lower flanges is excellent to reinforce the concrete, but it must be embedded in the concrete at least 1 in. clear of the flange.

Great care and very wet concrete must be used in order to get a proper bond with the work above. If the under side of the flanges are packed first, and the edges of the expanded metal, or other bonding material, left exposed with the idea of being later packed in concrete arches or other filling, there will result a joint between the hardened concrete under the flange and the filling work that will admit engine gases which will rust off the reinforcing metal, and sooner or later the concrete below the flanges will drop off. This has happened, and it gives a bad name to concrete protection, while the fault lies with the method of doing the work.

The best results would be obtained from a design of iron work that would admit a form of matched boards suspended by wires about 2 ins. below the iron, and then to fill the whole with very soft, fairly rich, concrete. The outsides of girders or trusses should be covered as well as the inside. A great help to ordinary paint is a close sheathing of matched boards under the iron work, which presents a plane surface underneath. In this case the rush of air from the passage of the cars following an engine sweeps the gases from under the bridge, so there is very little opportunity for the acids to get in their work. Where the floor is framed in the ordinary way, the smoke lingers a long time under the bridge until it cools enough to drop out of the pockets of the framework by gravity.

The ordinary method of protection is by paint. This, for structures subject to engine gases, should not be made of metallic pigment of any kind. These gases where severe will cut the best lead paints as quickly as naked iron. Only inert pigments should be used. Carbon, graphite, or gums are not so affected.—J. P. Snow; B. & M. Ry.

(3) I do not know of a thoroughly good protection against smoke, gases, and cinders which is practicable of application on overhead bridges. We have used paint in liberal quantities, and at frequent intervals, to endeavor to preserve our structures, but not with entire satifaction up to the present, though we hope by more liberal and frequent use of first-class paint to improve the conditions. —R. H. Reid; L. S. & M. S. Ry.

(4) The best method of protecting low overhead structures from smoke and gases and from blasts of locomotives is to keep the structures well protected with a good quality of paint. There are paints specially made for protecting against locomotive smoke and gases that I believe would stand the test. I do not think it is practicable to cover them on the under side, as I would consider it a dangerous practice. The covering might become loose, and by sagging, cause an accident to men on top of freight cars while trains are passing under, or it might fall on the train and do damage.—J. S. Berry; St. L. So. W. Ry.

(5) Only a small proportion of such surfaces will be subjected to blast action, usually not to exceed about 30 ins. in width directly over the centers of tracks. The subject should therefore be considered under two heads: A, metal exposed to gas only; B, metal exposed to gas and blast action.

A. Metal exposed to gas only, hot or cold, wet or dry, can be positively protected by coating it with any inert, incorrodible substance. Ordinary paint does not fill the bill. A coating of hot asphalt applied to heated iron has in some cases proved entirely effective. Care must be taken that the asphalt is so manufactured, or rather, refined, that it will contain little volatile matter, and of such origin and quality that it will not grow brittle and crack. It is easy to fail in either direction. Asphalt cut or dissolved in fluids, such, for example, as carbon disulphide, and applied cold, drying by evaporation, leaves a porous coating, and is consequently of little value unless burned or baked on. Possibly some other substance could be found which would improve the mixture.

Linseed oil, which forms the base of all ordinary paints, even when pure, is destructively affected by sulphurous acid. So, also, are most, if not all, varnishes. In many cases, however, especially of old structures, nothing but paint can be used, and it becomes necessary to make the best of a bad matter and use the best paint possible. Some experiments made eight years ago indicate the value of a paint made by adding powdered graphite to an ordinary red lead paint mixed as thick as brushes will work. The eight years' test shows that with not too severe conditions such paint, two coats, will last eight, and possibly ten, or more years. The red lead and oil form a cement which holds the graphite in place. The surface consists of graphite, which resists the action of acid and water as well as gas direct.

Any paint must be applied to a clean surface. This is difficult to obtain, but a necessity for success. The sand blast will do the trick, but it must be used with discretion. The sand will cut iron or steel surprisingly fast. Iron, when kept properly painted, should have little need of sand blast cleaning.

B. The sand blast action of a locomotive exhaust adds a very serious complication. On lines of heavy traffic it will cut through a 1-in. pine board in three months. About 30 trains a day starting from a station stop will cut through 1½ ins. of Portland concrete in about four years. Concrete reapplied will not last nearly so long. In a comparatively recent bridge near Boston the bottom flanges of I-beams were covered with a 1-16 in. sheet of lead. This lasted some six months under very unfavorable conditions. Possibly a ¼-in. plate would be better, as it would tend to cushion the blast action.

Another promising possibility is a cloth, not felt or paper, but woven fabric composed largely of asbestos or similar fibrous incombustible material soaked in raw asphalt, that is, asphalt of decidedly sticky, pitchy nature. This should cushion the blast, protect the iron, be easily applied, and not too expensive. Either the lead

*The statements here given were presented as the report of a committee at the annual convention of the Association of Railway Superintendents of Bridges and Buildings, at Chicago, Oct. 18 to 20.

or asphalted cloth could profitably be limited to a width of say thirty inches directly over track center, as only there is the sand blast effect seriously destructive.—H. K. Higgins.

6. In connection with work on which I have been engaged during the last 15 years, wood sheathing, made from tongued and grooved stock, properly supported, has been used with fair success, but is not entirely satisfactory on account of shrinkage, allowing gas to escape through the cracks and also danger of fire. A simple coating of paint is of no use whatever. Some mixtures of asphalt and black oil, applied hot, have stood much better than paint. The most satisfactory protection has been Portland cement plaster, attached to metal work with expanded metal, the plaster being put on in two coats; first a scratch coat, made up of cement, lime, and sand about ¾-in. thick, and the second coat Portland cement and sand, 1 to 2. It is quite necessary with this plaster protection to prevent any moisture from reaching the work, as the action of frost will disintegrate the protection. In the train shed at the Boston Terminal, it is found that the cold condensed gases from locomotives do most damage; in some cases completely destroying 14-ounce copper in less than two years. Hot locomotive gases seem to have very little effect on the metal work where the latter is not exposed directly to the blast.

7. Until recently, nothing but paints have been used by our company. These have all been unsatisfactory. A short time ago some steel bridges in Fall River, Mass., were plastered over with Portland cement and sand, about 1 to 2. This was put directly on the steel, about ¾-in. thick, with a reinforcing of wire cloth in the center. If this does not flake off or crack by the water getting in from the top, it should protect the steel.—J. B. Sheldon; N. Y., N. H. & H. Ry.

THE DRAINAGE OF INNER BASINS, MISSISSIPPI LEVEE SYSTEM.*

By Chas. LeVasseur.†

The extension of the levee system along the Mississippi river has brought to the immediate attention and study of the engineers of this region a problem of great importance.

This problem is "the drainage of the areas inclosed by the completion of the levees."

The conditions existing then have gradually changed. The country has since been cleared and placed under cultivation. The extension of the levee system has, year after year, closed the outlets of the natural drains, creeks or bayous flowing toward the river, and the network of streams or small natural canals composing the self drainage of the various basins toward the main drainage tributary have been choked by drift or otherwise to such an extent that they are now unable not only to take care of the surplus of drain water which cannot find an exit directly into the river, but even to discharge the drainage flow of their immediate watershed.

The result of these gradual modifications in the physical conditions of the basins is that numerous localities which, during the high water period, are protected by the levees from the river flood, are irremediably inundated, back of the levee embankment, by drainage and seep water. This inundation is regarded by the planters and farmers living along the Mississippi as more destructive than that due to the river, prior to the levee construction, and some of these gentlemen are blessing the levee protection in particular, and the engineers in general, claiming to have been, by the extension of the levee system, thrown from the frying pan into the fire.

This state of affairs calls for early investigation. Plans for relief will have to be formulated very soon.

But the problem for the general drainage of the inner basins is not so readily solved, as it seems possible to do so only by a general study of their physical features, and notwithstanding that the topography of the areas inclosed by levees along the Mississippi river seems to facilitate the drainage of the different basins, the highest land to be found being on the bank of the river, then gradually sloping back to the natural drainage tributary, which is generally situated near the hill ground, the operation is a difficult and expensive one, and may and certainly will involve the creation of canals, ditches and drains in the lowest levels, with, most probably, works for the regulation of flow at their outer or lower extremities.

The intention is not to enter to-night into the discussion of a general drainage system. The magnitude of such a problem is not only too vast for such a short paper, but this drainage question. Without this information [illegible] eral plan of relief cannot even be outlined.

Since a year or so ago several drainage boards [illegible] been organized, and in some of them work on a [illegible] scale has been started. But these boards are only [illegible] and their work may or may not help a future [illegible] drainage scheme.

It is thought, or at least hoped, that before long the various existing levee boards, or, better still, the United States Government, will take up this drainage question and that a complete system of drainage will be formulated for each of the various levee basins and carried on simultaneously with the present extension of the levee system.

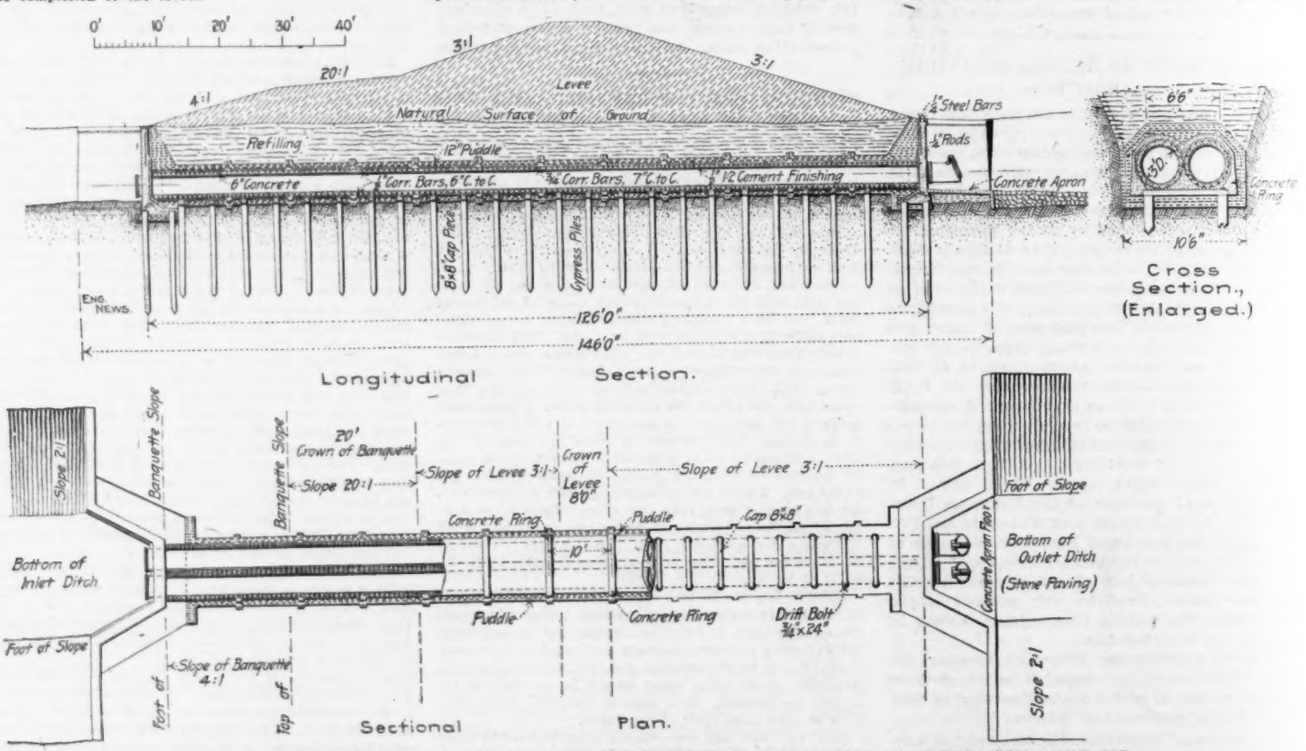
In this sketch the problem presented in the comparatively small areas of territory situated immediately behind the levees, and having no outlet for the drainage of their watersheds, will only be taken into consideration and the method of disposing quickly of the accumulated drainage water briefly described.

Up to now, in the upper levee districts, no engineering methods have been employed to that effect. One mode of getting rid of the drainage water accumulated behind the levee over the small inner basins during the period of the river high stages was simply to cut, as soon as the river had receded within its banks, the levee embankment and let the water find what exit it might choose.

This mode of operation, very primitive, to say the least, has great inconveniences. The current of the back water takes away generally more levee than it was anticipated, and sometimes, as was the case this year, the flood wave once passed is followed by a second wave of nearly the same amplitude, and before the drainage cut can be closed, the land back of the levee is inundated to a greater extent than by the drain water accumulated during the period of the first wave. The cut, under the river current, becomes a regular crevasse and large expenditure of money is necessitated in replacing, after the flood, the levees in their original condition.

In some districts levee cutting as the mode of drainage through levee embankments is not practiced. Syphons are placed over the levee and are depended upon to drain the back water. But syphons are at the best slow in their operation, need constant attention and answer for the drainage of very small areas only.

The Mississippi River Commission had in the past been



DETAILS OF DRAINAGE CULVERT FOR UPPER ST. FRANCIS LEVEE DISTRICT, NEAR BREWER'S LAKE, MO.

Ten years ago this question was not thought of. The territory adjacent to the river was comparatively scantily settled and the levees were, in some districts, beginning to be erected, in others, only partly completed. The drainage of the inner basins was left to take care of itself, either by the means of the creeks or bayous, left open, discharging directly into the river, or by numerous natural small drains reaching the low portions of the different basins and finally emptying into the river through the natural drainage tributary, generally situated near the hills.

the notes, figures and data necessary to formulate intelligently a plan for the general drainage of any basin are not in existence.

As stated above, this question previously was not given much attention, if any. The main point, up to the present date, it may be said, was to construct by any possible means and manner, and in the shortest time, with the least possible expenditure of money, the most mileage of levee, regardless of what has been sometimes called and too often regarded as side details, the drainage. Also, the different local boards have neither made accurate surveys and studies or collected necessary data bearing on

opposed to the construction of troughs or culverts, through the levee, as such structures may be a cause of danger to the stability of the embankment during the flood time. But this year, on the special recommendation of Capt. E. W. Van C. Lucas, U. S. A., the commission has authorized the construction of a culvert through the levee in the Upper St. Francis district, to drain the Brewer Lake territory.

This Brewer Lake basin may be taken as typical for the small inner basins situated immediately behind the levee embankment. This basin, including the territory lying between the river and some ridges west and south, Russ

*Slightly condensed from a paper published in the "Journal of the Memphis Engineers' Society" for March, 1904.

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Walnut ridge, has an area of about 12 square miles and can possibly be drained only by an old river bed, called Brewer Lake, which runs north and south. The levee, which is constructed from Bird's Point southward, cuts off the drainage outlet of this watershed.

About two-thirds of this territory is under cultivation, and it was calculated that the lake used as reservoir will be called upon to store about 110,000,000 cu. ft. of drainage water during the next overflow period.

Brewer Lake has a length of 7¼ miles; its average section available for storage is 2,850 sq. ft.; its storage capacity is about 104,000,000 cu. ft., and seems to be about sufficient to take care of the drained waters during the maximum duration of the high water.

The culvert to be constructed was required to be able to discharge the accumulated water in about 15 days, which means with a head of 2 ft., 85 cu. ft. per sec., and a velocity of about 10 ft.

Calculations were made for different forms of conduit, circular, egg-shaped, and with arch and invert of equal diameter, with a view of using only one conduit, but a plan having two chambers, 36 ins. diameter, was adopted finally.

Projects for different modes of constructing and different sections for the conduit were considered. The general idea followed in the plan is: Of a culvert 130 ft. long, having two chambers 36 ins. in diameter, the inlet and outlet of the conduit to be provided with proper retaining and wing walls. The outlet to have a concrete apron floor and the outlet ditch to be revetted with riprap to prevent scouring. For the closure of the conduit, flap valves are adopted. The whole construction to be made secure from leakage by being inclosed in puddled clay.

The different plans submitted were:

(1) Cast-iron pipe and concrete conduit.—The conduit is composed of cast-iron pipe 36 ins. in diameter, ⅜-in. thick, placed on pile foundations and covered with concrete inclosed in puddled clay. Puddle rings are located 12 ft. c. to c. to prevent all percolation of water along the line of conduit.

(2) Terra cotta pipe and concrete conduit.—Terra cotta pipes 36 ins. in diameter, 2½ ins. thick, are used for the conduit, and railroad iron instead of piling for foundation. The whole is covered with concrete and inclosed in puddled clay.

(3) Steel concrete.—In this method of construction (see illustrations.—Ed.) corrugated steel bars ¾ and ½-in. are used as a frame for the conduit, which is entirely of concrete, in proportions of 1, 2 and 5. The chambers are revetted with ½-in cement wearing coat, which is built simultaneously with the concrete filling. The foundations are piling, 5 ft. c. to c.

This last method of steel concrete was selected as offering the greatest security and strength for such a structure. The retaining and wing walls and outlet apron were similar in every case. The walls are to be of steel concrete backed with puddle. The approximate quantities of material required are:

Excavation, 1,500 cu. yds.; piling (round), 860 lin. ft.; cap pieces, 700 ft. B. M.; drift bolts, ¾ × 24 ins.; puddle, 100 cu. yds.; concrete, 127 cu. yds.; metal, 1,845 lbs.; stone paving, 570 cu. yds.; section of 36-in. pipe with valve, two number.

The price is estimated at about $4,000. This method of drainage through the levee will be, it is expected, followed in many localities offering the same physical features as the Brewer Lake territory. When this will be done it will relieve a number of acres from back water inundation, will be a great advantage to the planters of these small inner basins, and will certainly be the beginning of a systematized drainage of the rich and fertile country lying on each side of the Mississippi River, which, once protected from the river flood by a complete levee system and well drained back of the embankment, will be one of the richest agricultural countries of the world.

UNIFORMITY IN MARINE BOILER SPECIFICATIONS.

The American Boiler Manufacturers' Association has for some time been endeavoring to secure the passage by Congress of a bill to secure the revision of the boiler laws and regulations as now embodied in the rules and regulations of the Steamboat Inspection Bureau of the Department of Commerce and Labor. A report on the progress made during the present year was read at the meeting of the Association at St. Louis, in October, by Mr. E. D. Meier, Chairman of the Committee, and we give below an abstract of this report, as well as the bill which was submitted but which, as stated in the report, was withdrawn when the Department of Commerce and Labor introduced a bill of its own, the latter not meeting the approval of the Association:

In January, 1904, Senator Frye, the Chairman of the Senate Committee on Commerce and Labor, and Gen. Grosvenor, Chairman of the House Committee on Merchant Marine and Fisheries, agreed to introduce our bill. Rear-Admiral Melville also wrote a strong letter to Gen. Grosvenor favoring our bill. On Feb. 11, I called on Secretary Cortelyou, who referred me to Assistant Secretary Murray, in whose charge he had given this whole question of revision of the steamboat inspection laws. The latter gave me an extended interview, in which our bill was fully discussed. He seemed to object mainly to the provision for paying the expenses and the time of the commission which our bill was to create. But I explained to him that in a matter of public service and for a commission which was to be chosen as representing the various interests involved, it would be an injustice to ask the members to contribute their time without reasonable compensation. He did not, however, commit himself in any way, and it was not possible at that time to obtain a report from the Board of Supervising Inspectors on this general subject.

In the meantime I had written to Prof. Edgar Marburg, Secretary of the American Society for Testing Materials, and he sent copies of our bill to every member of the executive committee of his society, which had already expressed its concurrence with the general objects of our movement. On Feb. 27, your chairman met the Association of American Steel Manufacturers in Pittsburg, by appointment, and addressed them on the subject of our bill; explaining fully the difficulties we had met with and the impossibility of getting redress from the Board of Supervising Inspectors, which was limited in its action by antiquated but rigid U. S. statutes regarding the subject. The association appointed a committee, of which the President, Mr. McLeod, was chairman, to co-operate with us. Mr. McLeod went to Washington, visited Secretary Cortelyou and warmly advocated our bill. Secretary Cortelyou expressed himself favorably as to the necessity of revision of the existing laws and rules, but took the ground that a commission was not necessary, but that with certain changes in the laws he (the Secretary of Commerce and Labor) could, with the assistance and advice of the Board of Supervising Inspectors, meet all the difficulties and objections of which we complained.

On March 28, Secretary Cortelyou forwarded his bill to the Senate Committee on Commerce and Labor. On April 19, Senator Frye wrote me that the bill had passed the Senate; on the same day Gen. Grosvenor informed me that the bill had been reported favorably by the House Committee on Merchant Marine and Fisheries, and that it would be pressed in the House. On April 23, the secretary wrote me that he thought it was very doubtful whether his bill would pass during the present session.

Secretary Cortelyou's bill covers several rational and necessary changes in existing regulations, but it does not go far enough, nor cover enough ground in these specific changes. But there is one vital change suggested, which, if it becomes a law, practically places the whole subject of rules and regulations in one man's hands; i. e., the man whom the changes of politics may have placed in the responsible position of Secretary of Commerce and Labor. In the present law it is necessary before any change can be made, to have a recommendation by the Board of Supervising Inspectors, which must be approved by the Secretary of the Department. In the proposed law this procedure is indeed left as one means of attaining this object. But there is another and more direct method by which the Secretary can ignore the recommendations of the Board or fail to ask for any, and can make rules of his own volition, which would have the force of law.

If under the present law, courts have decided that certain regulations become void from the fact that the present method of procedure, as above described, virtually gives an executive officer legislative powers, which is contrary to the spirit and the letter of the constitution, then how much more may courts be expected to overthrow regulations made without any reference to a Board of Experts by an officer who is an inherent part of the national executive. This question is, of course, one for constitutional lawyers to decide. But if courts have and can so hold, any regulation which may be attacked by an interested party may be cancelled and chaos might result. Your committee is convinced that matters of such grave importance to life and property as are covered by the regulations of the steamboat inspection service, should be in their general lines so defined by law as not to be dependent on the judgment and special knowledge of a single officer.

We believe therefore that the appointment of a commission, as outlined in our bill of 1903 and 1904, should be insisted on, alike in justice to the great interests directly affected by the steamboat inspection law and for the benefit of the general public, whose feelings have been strongly aroused by the tragedy of the "General Slocum" in New York Harbor. It is quite likely that this mightily aroused public opinion will compel a revision of the entire steamboat inspection law far exceeding the modest limits in which your committee was working.

BILL AS PROPOSED BY THE COMMITTEE ON UNIFORM BOILER SPECIFICATIONS; AMERICAN BOILER MAKERS' ASSOCIATION.

A bill to increase the efficiency and safety of the mercantile marine of the United States by creating a commission to revise the laws relative to construction, installation and inspection of marine boilers, to provide uniformity of inspection of marine boilers in the United States and insular possessions, and for other purposes.

BE IT ENACTED by the Senate and House of Representatives of the United States of America in Congress assembled,

That the Secretary of the Department of Commerce and Labor is hereby empowered and directed to appoint a commission of not less than five nor more than seven members, representing commercial, manufacturing, maritime, and military interests, whose duty it shall be to recommend to the Congress such changes in the Revised Statutes of the United States as will bring about the improvement of the construction and secure a uniformity of inspection of all marine boilers and their appurtenances. It shall likewise be the duty of the commission to recommend such changes in the law as will bring about a reciprocal recognition of boiler inspection certificates between the several maritime nations having marine inspection laws, thus preventing the shipping industry of the country from being subjected to vexatious and costly delays in foreign harbors, resulting from the incongruous laws of the several maritime countries, appertaining to the construction, inspection, and operation of marine boilers.

Sec. 2. That this commission shall be appointed by the Secretary of the Department of Commerce and Labor, and they shall submit to him a preliminary report on or before ..... That the expense of preparing such a report shall be chargeable to the appropriation created by this act. That any interested parties making official request for such document shall be furnished a copy by the Department of Commerce and Labor. That all interested parties shall have an opportunity to submit to the commission any protest, suggestion, or recommendation in regard to changes or amendments that should be made in the preliminary report. That the commission shall carefully consider such protest, suggestion or recommendation before making their final report to the Secretary of the Department of Commerce and Labor for transmission to the Congress. Such report shall be submitted to him on or before ..... That this commission is further empowered to advertise in technical papers, employ technical experts and clerical assistants; likewise to conduct any experiments and tests.

Sec. 3. That in order to defray the expense attendant upon the duties and labor of such commission the sum of $25,000 is hereby appropriated, out of any money in the hands of the Treasurer of the United States not otherwise appropriated. That the salaries of those members of the commission not holding official positions under the government shall be determined by the Secretary of the Department of Commerce and Labor.

A REMARKABLE ACCIDENT TO A MASONRY ARCH BRIDGE.

On June 27, 1904, a large two-span stone arch bridge which was being built across the River Isar at Munich, Germany, was totally wrecked by an accident of most unusual nature. On that date the two arches, which were built three-hinged, slipped off their hinges; the two arches dropped bodily down some 12 ins. until the hinge shoes came to a bearing on the granite skewback blocks of the abutment masonry. As there is no practicable way of raising the arches back into place, they will have to be taken down and rebuilt. The first complete description of the nature and effects of this accident is given in a recent issue of the "Zeitschrift des Vereines Deutscher Ingenieure," from which the following article has been prepared.

The River Isar is divided in Munich by an island; the bridge crosses the right (east) arm of the river and received the name Outer Maximilian Bridge. It comprises two arched spans of cut stone masonry, each 144.3 ft. in span between centers of skewback hinges. Both arches are three-hinged, although (following a plan rather common in Europe) the hinges were intended to be filled solid by concreting, after the full dead load was in place. The roadway of the bridge is 72 ft. wide in the clear, of which the central 40 ft. forms the roadway. The barrel of the arch is 71.5 ft. wide. The roadway has an up-grade of 5.7% toward the east, that is, from the island toward the main bank.

The arch was designed to be of what we may call the "free-ring" type, i. e., the load of the roadway was transmitted to the arch ring by separate (concrete) piers carrying relieving arches, except near the center, where the depth is too low for this. The arch ring was built of limestone ashlar, except that the courses next to the hinges were of granite. The face rings, of cut limestone, were lapped across the hinges so as to conceal the latter.

A skeleton elevation of the bridge is shown in Fig. 1 herewith, which represents also the condition of the work at the time of the accident. Both spans had been completed, as far as concerns the arch rings; in the west span the centering had been wholly removed, while in the east span the centering was still in place, though slacked away so as to clear the arch three or four inches at all points. The centering of both spans had been slacked away simultaneously, on June 13, just two weeks before the accident. At the time of slacking centers, both spans had been completed to the condition represented by the west span in

Fig. 1. Since that time the work of placing the secondary arches in the east span had been in progress, and these had been nearly completed; the west span was still in the condition shown in Fig. 1.

For an understanding of the accident it is important to comprehend the hinge construction used. Fig. 2 gives details of the skewback hinges. Each hinge joint contained 33 individual pairs of hinges, spaced 26 ins. c. to c. along the joint. Each pair

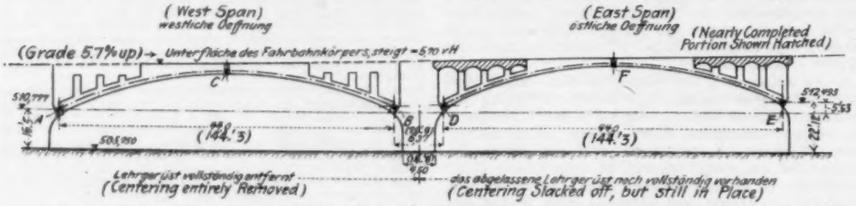


FIG. 1. DIAGRAM ELEVATION OF THREE-HINGED MASONRY ARCH BRIDGE AT MUNICH, BAVARIA.

This drawing shows also the stage of construction at the time of the accident, June 27, 1904.

comprised an upper and a lower cast-iron shoe, in the face of which was embedded a bearing plate made of steel casting. The bearing plates had cylindrically-curved faces; the upper plate was convex, with 12-in. radius, the lower plate was concave, with about 10-ft. radius. The cast-iron shoes carrying these plates were similar, and both of them bore against the granite skewback blocks by means of sheet lead plates interposed between the stone and the cast iron. In addition, the lower shoe was held in place by iron dowels entering the granite, but the upper shoe had no such fastening.

The hinge joint at the crown was quite similar to the skewback hinges, except that in this case

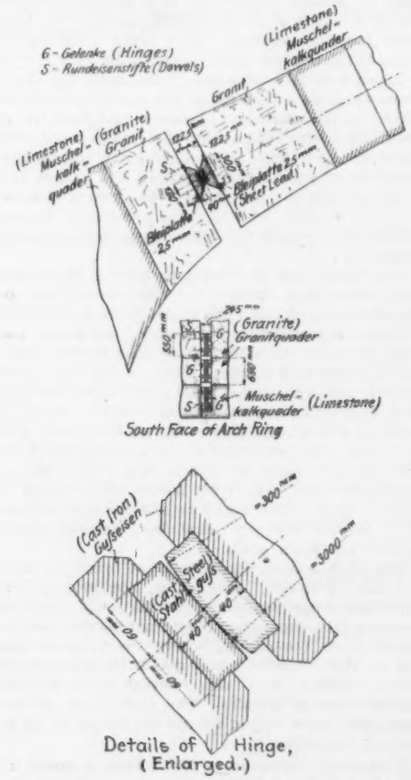


Fig. 2. Details of Skewback Hinges of Three-Hinged Masonry Arch Bridge at Munich, Bavaria.

both sets of shoes were doweled to the stone. The curvature of the surfaces of the bearing plates in this joint is not stated in our source. However, as great care was taken at all times during the erection to keep the arches symmetrically loaded, the curvature of these faces has no direct relation to the accident.

On the morning of June 27 a set of levels was taken on the bridge at 7 a. m. The west span was found to be in normal position. The east span, however, showed a rise in the crown, amounting to about ½-in. At about 9 a. m. it was observed that the eastern skewback hinge of the east span (hinge E in Fig. 1) had become displaced, the arch having slid down relative to the abutment, about ¾-in.; the movement increased to a total of over 1 in. by 1 p. m. In the meantime the westerly skewback hinge (D in Fig. 1) of the same span was also sliding in the same way, but the motion here was even more rapid than in the opposite hinge. In both joints the movement was uniform along the entire length of the joint (width of the bridge). At 1.30 p. m. the movement had progressed so far that one of the two hinges reached the edge of the bearing plate (see Fig. 2), and the whole arch dropped bodily 12 to 14 ins., or until the upper shoe at each skewback hinge came to bearing on the face of the granite of the abutment. Fig. 3 sketches the position after the fall.

The west span had up to this time showed no movement, but simultaneously with the fall of the east span, and probably caused by the shock of this fall, it also slipped off its end hinges into a position like that of the other span. The combined fall caused a shock which was felt like an earthquake in the city, to a considerable distance from the bridge.

The center or crown hinge of the east span (hinge F) was thrown out of line by the fall, as also sketched in Fig. 3, to the amount of ¾-in., uniform along the length of the joint. The west span, however, showed no displacement of the two halves of the arch at the crown joint, except that two pairs of hinges at one end of the joint were shifted out of place.

The effect of the fall on the arch was to spall off many of the face stones near the hinges, damage a number of the granite skewback blocks, and crack off many of the concrete piers on the arch-ring which carried the roadway. Otherwise the masonry work does not appear to be badly damaged. Whether the piers suffered damage is probably not yet known.

The hinge joints, whose general position after the fall is shown in Fig. 3, evidenced a different behavior of lower and upper hinge shoes. The lower shoes, which were fastened to the granite by iron dowels, were not shifted from place. Of the upper shoes, a large number fell out altogether, and many others were shifted from their original position relative to the arch; these upper shoes, it will be remembered, were not fastened by dowels.

The amount of the vertical drop of the structure was 12 to 14 ins. at the skewbacks (slightly different at the four hinges); the drop at the crown was 4.3 ins. for the west span (hinge C) and about 1 in. for the east span (hinge F). Since the centering of the east span was still in place at the time of the accident (though slacked away to clear the masonry by three or four inches), this span in part fell upon the centering and did much damage to the woodwork, crushing many of the cap timbers.

This most peculiar accident was thoroughly investigated for its cause by the author of the article cited, Mr. W. Dietz. Primarily several facts relating to the design of the arches and the method of construction used must be noted:

(1) The skewback hinges were not in the same horizontal plane, but lay in a plane rising toward the east on a grade of 1.8%. In consequence of this, if the arch loading were symmetrical about the crown, the crown thrust would not be horizontal, but would have about the same inclination as the plane of the skewback hinges, about 1°.

(2) The contact surfaces of the crown hinges were vertical, instead of being placed normal to the pressure curve; hence the crown thrust always had a tangential component of about 0.018.

(3) None of the hinge joints were provided with dowels connecting the rolling surfaces. Thus if at any joint the pressure line were not truly normal to the contact surfaces, then the tangential component would be resisted only by the friction between these surfaces.

(4) The pressure line for full loading was computed to be normal to the surfaces of the skewback hinges. Then, to guard against maximum divergence of the pressure line from this normal, during erection, great care was taken to have the arch loaded symmetrically about the center line at all times. However, it would be impossible during construction to arrange the loading so uniformly that the pressure line at the skewback hinges would always lie exactly normal to the contact surfaces.

(5) The steel contact surfaces of the skewback hinges were, it was later discovered, carefully cleaned and smoothed and had then been given *a coating of stearin*. The coefficient of friction was thereby brought down to a very low figure, much lower even than if the surfaces had been lubricated with ordinary oil.

A careful calculation of the hinge pressures, under the condition of loading existing at the time of the accident, showed the direction of the abutment pressures to be as shown in Fig. 5. The hinge pressures in the west span diverged only very slightly from the normal, respectively 4′ 35″ and 35′ 11″. But in the east span the concrete work of the secondary arches and roadway caused a rise of the pressure line at the haunches, so that the hinge pressures diverged from the normal at the skewbacks by amounts exceeding one degree, respectively 1° 43′ 29″ and 1° 15′ 30″. Hinge D is the joint showing maximum divergence, it appears, and this is undoubtedly the joint at which the slipping started, as already recounted.

It is noted by Mr. Dietz that in the finished

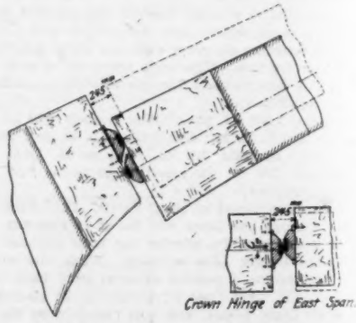


Fig. 3. Sketches of Displaced Hinge Joints.

Note: The skewback-hinges were displaced in precisely similar manner in both spans, but the crown-hinge sketched above represents the condition of the east span only; the crown-hinge of the west span showed no displacement of the two halves of the span relative to each other.

bridge the worst position of live loading (80 lbs. per sq. ft.) would have caused a divergence of 2° 6′ 15″ at the skewback hinges; the tangent of this angle is 0.03674, which represents the part of the total thrust which would have been resisted by the friction of the hinge surfaces. The divergences computed for the position of loading at the time of the accident are considerably less than this amount, so that it might be concluded that if the accident had not happened during construction, it would possibly have taken place later, when the bridge was in use, when a maximum live loading chanced to come on only one half of the span. However, it is to be remembered that the hinges were to be filled solid with concrete after the bridge was completed, and this concrete would have aided in carrying the shear at the hinges.

The actual hinge pressures, or rather their normal and tangential components, existing at the time of the accident were computed as follows:

Hinge.	Normal thrust.	Tangential Component.
....	228,000 lbs.	300 lbs. up.
....	225,000 "	2,450 " up.
....	205,000 "	3,600 "
....	260,000 "	7,800 " down.
....	256,000 "	5,500 " down.
....	230,000 "	4,000 "

As the length of hinge was, in each joint, equal to 33 × .55m., or 59.5 ft., the normal pressures per inch of length, average for each joint, are found to be 320, 315, 285, 365, 360, 320 lbs. respectively.

THE USE OF COPPER SULPHATE TO PREVENT ALGAL GROWTHS AT HANOVER, N. H.

By Prof. Robert Fletcher,* Assoc. Am. Soc. C. E.

The water-works which supply Hanover are owned jointly by the village precinct and Hanover College, under the name of the Hanover Water-Works Co. The storage reservoir is some 700 ft. above sea level, and is formed by an earth dam 720 ft. long, thrown across a small brook. The reservoir receives the drainage of about 1,200 acres of land, a district of which the water company recently obtained exclusive control by the purchase of the farms; and since last autumn there have been no actual residents in the area. The subsoil is boulder clay or hardpan. It is about one-half covered with a forest growth of hardwood and pine. The remainder is divided between hay and pasture land. Part of it has steep slopes, which drain off rapidly; about one-half has gentle slopes, which retain the rainfall and deliver it slowly into the reservoir. The second year after the reservoir was built it was stocked with fish and it now contains a large number of black bass. A year ago these fish became numerous.

The reservoir has been in use since its completion in November, 1893. The flooded area, which was gross land, was not stripped, but the top soil was only a few inches thick, overlying blue clay hardpan. All tracts of the sod have disappeared, and the exposed margin at low water are now clean and sandy.

In the early summer of 1904 the water became somewhat offensive to users in the village, being discolored from dissolved organic matter and having the so-called "fishy" taste. Our resident bacteriologist, who is also bacteriologist for the

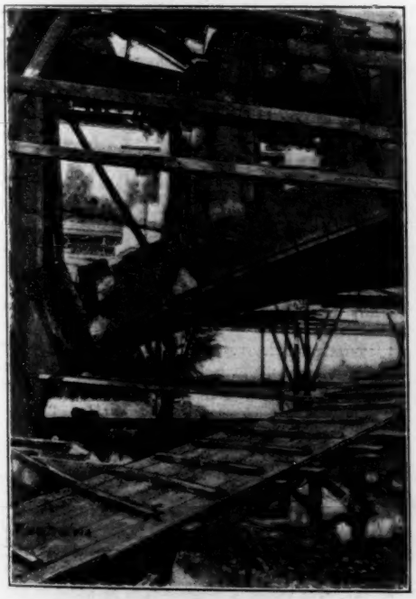


Fig. 4. View of One of the Skewbacks After the Accident.

State Board of Health, had made frequent observations of the water since the early spring. He had noted the gradual development of algae growth, so that at the time referred to he was obtaining about 600 organisms per cu. cm. of water. None of these organisms at that time were visible to the naked eye. At that stage I laid before our board of directors the ascertained facts, including official statements, concerning the use of copper sulphate for the purification of water affected with algae. The board voted to have a test made on our reservoir, under the immediate supervision of the bacteriologist, which was done without delay, he being aided by myself and by the superintendent of our water-works.

The estimated contents of our reservoir at that time was 100,000,000 gallons. On the recommended ratio of 1 part in 4,000,000, we applied

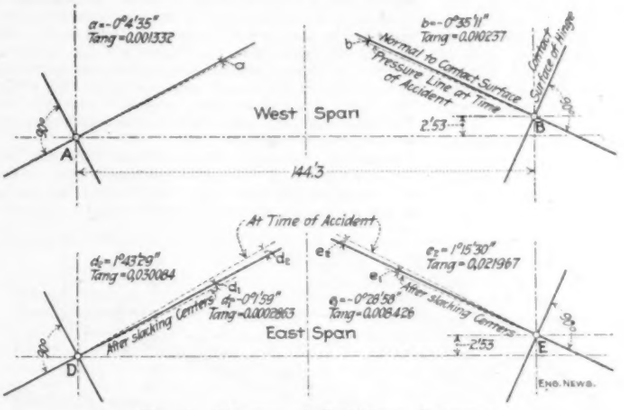


Fig. 5. Diagram of End-Hinge Pressures.

200 lbs. of copper sulphate in the following manner: A bag of burlap was prepared so as to be stretched over a square iron frame. Into this 25 lbs. of copper sulphate was placed and the whole suspended from the stern of a boat. The boat was then rowed at a suitable rate of speed from the deepest to the shallowest margin. This course varied from 2,000 ft. to a few hundred. Returning, the course was taken about 25 ft. from the first one. Usually the sulphate would be dissolved in one trip out and back, 20 to 25 minutes. The material was all distributed in a similar manner and apparently quite uniformly diffused. The copper sulphate was applied on July 18, and the work occupied a little more than five hours.

Within 24 hours after the treatment a sample of the water showed only 60 organisms per cu. cm. Within something over 40 hours it showed less than ten, and after about 60 hours there was no trace of the organisms obtainable by laboratory methods. Further daily observations continued from that time failed to show any trace of the organism, and no harmful effects in the way of destruction of fish in the pond. The improvement in the quality of the water was immediate. The taste disappeared, the color was so reduced as to excite no remark, although this was probably due to the favorable conditions of sunlight and air circulation; and there was no recurrence of the difficulty during a period of some ten weeks. During the last week in September the bacteriologist informed me that he had obtained a slight indication of the recurrence of algae since the stagnant period of late August and September, but there is no indication of that discernible by the consumer. During the two months just named, the water in storage was reduced to about 70,000,000 gallons.

*Director Thayer School of Civil Engineering and President and Engineer of the Hanover Water-Works Co., Hanover, N. H.

COST OF DITCHING CUTS AND WIDENING EMBANKMENTS.*

In considering the question of the cheapest method of ditching cuts and widening embankments, it is found that there is not only little published bearing directly on that subject, but that statistics regarding costs of work actually done are seldom available, where all the details connected with the work, such as length of haul, kind and condition of material, number of men employed, number of yards removed, lost time through various causes, wages of men, yards handled per train, etc., are known or, if available to a few, such statistics are not worked up into such shape that they can be presented in a complete and simple form to aid in properly determining the best method to pursue in any particular case.

With a view of placing such information in a convenient form, and also to enable one to see at a glance the effect on the cost per yard of various changes in the number of men, etc., two diagrams have been prepared, which are made a part of this report, one showing the estimated cost per cubic yard for a haul up to 7,500 ft., and the other up to 15 miles. The former, Fig. 1, being to a larger scale than the other shows the relative cost by various methods in better shape, and is, consequently, the one considered in this discussion. The latter, Fig. 2, can be used to advantage only in determining whether it is cheaper to make a long haul from the point where ditching is being done, than to waste the material obtained from ditching and obtain the material for widening banks from a more convenient location. Both diagrams are based on the same unit prices, and have been prepared from estimates, after consulting Trautwine's "Pocket Book," Gillette's "Earthwork and Its Cost," Camp's "Notes on Track," and Tratman's "Railway Track and Track Work," the results being compared with actual costs where such have been available with all conditions known. As it is seldom that ditches are cross-sectioned, in order to know beforehand the exact number of yards to be removed, it is not expected that the diagrams will assist very much in estimating what the cost of ditching a certain cut will be, but if they are fairly accurate they should show very closely how the work can be handled to the best advantage after the estimate is made, and their careful study may give suggestions of value.

In order to make this report as concise as possible, the detailed estimates from which diagrams were prepared are omitted, but are included in an appendix, so that the work may be checked in detail.

By examining the diagram in Fig. 1 it will be seen that the cheapest method of ditching where the material is to be used in widening embankments, and where such work is not done by simply casting across one track, is by a machine ditcher, provided the machine is so designed that it can load and dump 5 cu. yds. in not to exceed 2½ minutes, exclusive of running time, and can be operated by three men besides the train crew, and if the conditions are such that such a machine can be used up to a haul of some 1,200 or 1,300 ft. in very fair digging, or up to some 1,900 ft. in bad, wet digging. From this point on, a properly designed machine ditcher, so arranged that it can load a full train of material, used in conjunction with a plow and cable or other method for quick unloading, can be worked most economically. In both these cases of machine ditchers, it is assumed that the machines will be used enough each year to bring the cost for interest and depreciation down to the estimate given in the appendix, the number of yards handled having to be greater than estimated in case a more expensive machine is used than estimated on.

In case a machine ditcher is not available, a study of the diagram will show the relative cost per yard by various methods, provided the traffic is such that the actual working time of work train is only about 6 hours out of 10 hours the men are assumed to work each day.

TEAM WORK.—On light work banks can be widened very economically with teams and scrapers. This method can also be used to widen the base of heavy embankments, the filling being afterwards completed by work train or other means. The filling being compacted by the movements of the teams over it is less liable to settlement and unites closer to the old bank than by other methods. Work of this kind is usually let by contract, the price being from 14 to 25 cts. per cu. yd.

CASTING.—The cost of ditching by casting may in fair digging be taken at 10 cts. per cu. yd., where one cast will place the material in a suitable final location. If necessary to use one platform by which the material can be raised 6 ft. with the first and 4 ft. with the last handling, in order to place it far enough from the edge of the cut, the cost for such material will be increased about 6 cts. per yd., or to a total of 16 cts. per cu. yd. A description of a simple portable platform is given under the heading "Work Train and Hand Loading." In both of these cases the material cannot ordinarily be used to advantage in widening embankments.

WHEELBARROWS.—By this method the material excavated may be used to widen embankments, if conditions are favorable, and the cost is practically a constant to which a uniform addition is made varying directly with the length of haul. For fair digging it will be noted that casting is cheaper than any wheelbarrow work, and that casting with one platform is about the same cost as wheeling 125 ft. with wheelbarrows. If the material is merely to be carried across three or more tracks, where the traffic is so heavy that it is not desirable to lay gangways across the tracks, on account of safety, very fair results can be obtained by constructing boxes with

*Abstract of a committee report presented at the annual meeting of the Roadmasters and Maintenance of Way Association at St. Louis, in September.

two handles, similar to the handles on push or hand cars, on each end, and have two men carry each box across. This method, however, is more expensive than wheeling.

PUSH CARS.—As it is necessary to protect push car work by flagmen, the greatest economy by this method will be obtained by working as many men with two flagmen as can be worked to advantage. This is indicated by the three dotted lines showing 4, 10 and 16 men actually ditching under the protection of two flagmen. It is here assumed that 20% of the time is lost on account of the traffic, but that this 20% covers the time spent in trimming up the cut. On the diagram, the three dotted lines indicate cost per yard if the men shovel the material off the car; while the three full lines indicate the cost if the car is so arranged that the material can be dumped, by placing an entirely separate box, open at one side, on the bed of the car, or some other suitable method. By such an arrangement, the cost per yard can be reduced some 3 to 4½ cts. over shoveling the material off the cars.

WORK TRAINS AND HAND LOADING.—The diagram is plainly marked showing the method covered by each line, and it is only necessary to call attention to the fact that where only 60 cu. yds. are handled per trip, the lines are dotted lines, and full lines are used where 120 cu. yds. are handled per trip. In all cases with work train (except one) it is assumed that all the men employed go with the train to unload, and for this reason the cost with 50 men, handling 120 yds. per train, becomes less than with 100 men under the same conditions, after a haul of about 2,600 ft., or ½ mile has been reached. If, however, the work is properly handled the whole number of men employed (where such large numbers are used) are not sent with the train, but are kept at work at the ends of the cut ditching with wheelbarrows, or possibly casting the material, where such can be done by the use of a platform, while part of the men unload. The cost will thus be reduced considerably, it being possible, by proper arrangements, to reduce the cost to almost what machine ditchers will accomplish.

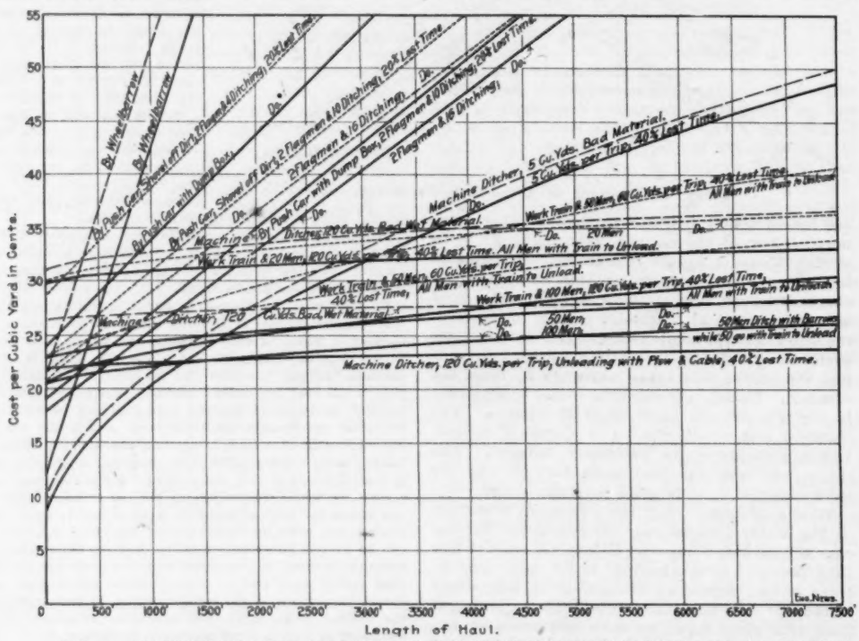

Cost per Cubic Yard in Cents.
Length of Haul.
Eng. News.
By Wheelbarrows.
By Push Cars, Shovel off Dirt, 2 Flagmen & 10 Ditching, 20% Lost Time.
By Push Car with Dump Box, 2 Flagmen & 10 Ditching, 20% Lost Time.
2 Flagmen & 16 Ditching, 20% Lost Time.
Machine Ditcher, 5 Cu. Yds. Solid Material, 5 Cu. Yds. per Trip, 40% Lost Time.
All Men with Train to Unload.
Work Train & 20 Men, 60 Cu. Yds. per Trip, 40% Lost Time.
Work Train & 50 Men, 120 Cu. Yds. per Trip, 40% Lost Time.
50 Men Ditch while 50 go with Train to Unload.
Machine Ditcher, 120 Cu. Yds. per Trip, Unloading with Plow & Cable, 40% Lost Time.

FIG. 1. DIAGRAM OF COST OF RAILWAY DITCHING BY VARIOUS METHODS, WITH HAUL UP TO 7,500 FT.

(Wages, 15 cts. per hour; train and train crew, $22 per day.)

Full and dotted lines indicate cost of easy and dry digging.
Dash lines indicate cost of wet and bad digging.
Dotted lines for push car work indicate unloading by hand.
Full lines for push car work indicate unloading by dump box.
Dotted lines for work train work indicate 60 yds. hauled per train.
Full lines for work train work indicate 120 yds. hauled per train.

A portable platform for carrying on the work trains for use in cases where material can be thrown out of the cuts by two castings, consists of two posts 2 × 6 ins., 12 ft. long, with two horizontal pieces 2 × 6 ins., 10 ft. long, running into the bank to support the platform of five boards 1 × 12 ins., 5 ft. long. The posts and horizontal supports are bored at intervals to permit adjustment of the height of platform. In a deep cut, a second scaffold may be placed above the first. This device was first furnished section foremen on the Southern Railway by Mr. W. A. Fort, Supervisor, but was found to be of such value as a time saver when trains were late, that ditching trains were equipped with them. One man on the scaffold can handle about as much dirt as two men can handle in the ditch.

On this diagram the question of using two or more work trains with a gang of say 100 men loading, the unloading being done at a distant point by plow and cable, has not been considered, as work of such character would vary to such an extent with the local conditions, that it would necessarily have to be considered specially for each individual case. It may be mentioned, however, that 100 men could load 1,000 cu. yds. of material already loosened and placed conveniently for loading, in four hours actual working time and at that rate the total cost for one train amounting to say $22 per day, would be but 2.2 cts. per cu. yd. In order, therefore, to keep such a gang busy, a sufficient number of trains should be used, if conditions, such as traffic, side track facilities, etc., will permit. The whole question with work trains, therefore, resolves itself into equalizing the number and disposition of men employed, with the train service in such a way that one will not overbalance the other, and both will be in accordance with the requirements in regard to length of haul, traffic conditions, etc.

MACHINE DITCHERS.—These may be divided into two general classes: (1) Ditchers which load a scoop on one or both sides and then run to the end of the cut to dump the material, and (2) those which load a full train of material and unload by plow or by hand. The first kind can be used to advantage only where the haul is comparatively short, while the second class is economical for a long haul. The designing of a machine ditcher, or the selecting of one already built, in order to obtain the best results, requires careful study and consideration. Various styles have been described in the papers by Mr. Mead and Mr. Stanley before this association at its last meeting, and in Camp's "Notes on Track" and Tratman's "Railway Track and Track Work," and a repetition of these descriptions will not be given here. Two styles of the second class, however, the Mahoney ditcher, and the one manufactured by the Marion Steam Shovel Co., have not been described, their construction and operation being as follows:

The Mahoney ditcher* consists of a substantial steel frame work, with a mast and boom arranged to be handled by a hoisting engine or Lidgerwood unloader on a car next to the locomotive. The ditcher is lowered into the ditch and filled by the movement forward of the train, after which it is raised by the hoisting engine and automatically dumped directly in front of the steel frame work. The frame work is moved ahead on the car by means of the hoisting engine. It is stated that it requires less than one hour to change this machine from working on the left side to the right side of the train. It is claimed that this machine will do the work of 150 men in cutting ditches through wet clay and loading material on flat cars, with the aid of only three men besides the train crew.

*Engineering News, Jan. 7, 1904.

The Marion ditcher consists of practically a small steam shovel mounted on a frame or sled which propels itself over the top of the flat cars by means of a cable attached to its propelling drum, which cable operates over a sheave attached to one of the forward cars. It is stated that the dipper capacity is ½ cu. yd.

The requirements of a suitable machine ditcher, either class are that it shall be able to cut the full depth necessary, and close up to the ends of the ties in order to obtain a standard section; that it shall be quickly handled with the least number of men practicable; that it shall have the fewest possible parts likely to get out of order, and that it shall be capable of sloping the banks to fair shape either by a slope board or dipper under control of the engineman, the slope board probably being preferable even with the dipper. With either class of machine, the dipper or scoop should be as large as can be handled to advantage in order to reduce the cost per yard, machines of first class having very long scoops, while those of the second class have dippers somewhat similar to a steam shovel dipper of about ¾ to 1 cu. yd. capacity. As in the case of steam shovel work, the engineman or the man in charge of handling the scoop or dipper, should be thoroughly competent, as the cost per yard of material will be greatly increased if the shovel work is handled slowly.

In ditching with the Mahoney ditcher on the B. & O. S. W. Ry. during May and June, 1904, it was found that from 12 to 16 cu. yds. could be loaded every 30 minutes in wet or soft soil. The machine is probably not well suited for very hard digging, as the dipper is hinged to the beam, and the weight of the dipper is the only power it has to force itself into the soil. It would require about 30 seconds to move the ditcher ahead and required moving the machine three times for each car load. The crew used to operate this machine was one engine and crew, train crew and four men to operate the ditcher. This machine would not be suitable for ditching in rock cuts, where the ditch is not always the same distance from the track. The material excavated in this particular case was very wet and would have been exceedingly expensive to handle by hand. The record of cost of this work is given in the appendix. T. S. Forquharson, W. J. McDermont, V. K. Hendricks, C. E. Elliott, J. Murphey.

Appendix.

For the purpose of determining the actual cost of hauling by train, a diagram, Fig. 3, is made a part of this appendix, showing the number of minutes actual running time estimated to be consumed for the round trip for the various lengths of haul. By determining the cost per minute of the train and crew, and any other men who go with the train, the cost per yard for actual hauling can be determined from this diagram. It is assumed that this time diagram will apply to any train, whether it carries but 5 cu. yds. per trip or 120 cu. yds. per trip, although the short trains can, of course, be handled more quickly than the heavier ones.

The details of the estimated cost per cu. yd. for handling work by the various methods considered is as follows:

BY WHEELBARROWS.

For common loam, the cost is taken at:

	cts.
1. Loosening and loading on barrows	9.8
2. Leveling earth on embankments	.7
3. Repairs to tools	.2
4. Superintendance and water carriers	1.5
Total	12.2

To this fixed charge, a constant per 1,000 ft. haul is to be added, as follows:

Repairs to gangways	1.0 cts. per 1,000 ft.
Wheeling material	30.0 cts. per 1,000 ft.
Total	31.0 cts. per 1,000 ft.

In handling bad, wet material, it is assumed that the fixed charge will be increased 60%, or 7.3 cts. per cu. yd., while the cost of wheeling remains the same.

BY PUSH CARS.

If material is unloaded by shovel, the cost, exclusive of flagmen, is taken as follows.

	cts.
Items 1, 2, 3, 4, as before	12.2
Unloading push car	3.7
	15.9
20% lost time	3.2
Total cost per yd.	19.1

To this fixed charge a constant is to be added to cover the cost of hauling, amounting to 33.4 cts. per cu. yd. per 5,000 ft. haul. As this amount covers the actual cost without including flagmen, the cost per yard will be increased by half the total amount given above, if two men out of the gang of six are kept flagging while four men do the ditching. In case ten men do ditching while two men flag, the increase over the above figures will be one-fifth of these figures; and if 16 men ditch and two flag the increase will be one-eighth over the above cost.

If a dumping box, or some similar arrangement, is used on the bed of the push cars to unload quickly, the cost, exclusive of flagmen, is estimated as follows:

	cts.
Items 1, 2, 3, 4, as before	12.2
Unloading dump box	.3
	13.3
20% lost time	2.6
Total	15.9

To this fixed charge should be added a constant amounting to 33.4 cts. per yd. for 5,000 ft. haul to cover the cost of time consumed hauling. If two men are kept flagging, while either 4, 10 or 16 men are ditching, the portion of the above cost to be added is as given in the case of push cars unloaded by shovel.

BY WORK TRAIN AND HAND LABOR.

The cost for train and crew, coal, etc., is taken at $22 per day for work train, and the actual working time is

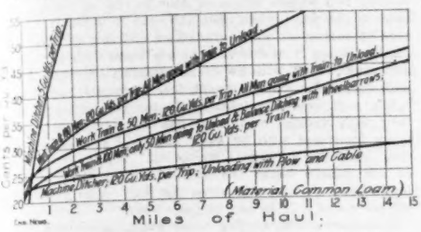

Work Train & 100 Men, 200 Cu. Yds. per Trip; All Men going with Train to Unload.
Work Train & 50 Men, 100 Cu. Yds. per Trip; All Men going with Train to Unload.
Work Train & 50 Men, only 30 Men going to Unload & Balance Loading with Wheelbarrows; 100 Cu. Yds. per Train.
Work Train & 20 Men, 80 Cu. Yds. per Trip; Unloading with Plow and Cable.
Machine Ditcher, 120 Cu. Yds. per Trip; Unloading with Plow and Cable.
(Material, Common Loam.)
Miles of Haul.

Fig. 2. Diagram of Cost of Railway Ditching by Various Methods, with Haul up to 15 Miles, where Digging is Easy.

(Wages, 15 cts. per hour; train and train crew, $22 per day.)

taken at 6 hours per day, allowing for 40% of the working hours to be lost time. With 20 men on train, the cost for handling common earth is estimated as follows:

	cts.
Loading (40% lost time used in loosening, trimming, etc.)	11.2
Unloading	3.8
Repairs to tools	.2
Superintendence and water carriers	1.5
Cost of train loading	7.3
Cost of train unloading	4.6
Total	30.1

To this fixed amount, the cost of train and crew, together with laborers during the time traveling to and from the place of unloading, is taken from the diagram showing time consumed in round trip of work train, the variable, of course, being twice as much per cubic yard if 60 yds. are hauled per train per trip, as it is in case 120 yds. are hauled per trip.

With 50 men and 100 men on the train, the estimate is as follows:

	50 men. cts.	100 men. cts.
Loading (40% lost time used in loosening, trimming, etc.)	11.2	11.2
Unloading	3.8	3.8
Leveling embankments	1.5	1.5
Repairs to tools	.2	.2
Superintendence and water carriers	1.5	1.5
Cost of train loading	2.9	1.5
Cost of train unloading	1.8	.9
Total	22.9	20.6

The variable to be added to cover the time of train crew and men traveling to and from the place of unloading is taken from the diagram, as in the case of 20 men with the train.

BY MACHINE DITCHER HAULING 5 YDS. PER TRIP.

It is assumed that all expenses connected with the train, including crew, fuel, etc., amount to $22 per day, and that there is an additional expense of $6 per day on account of labor for handling scoops, making the total cost $28 per day; and that but six hours actual time is worked per day, which makes the cost per minute 7.78 cts., or 1.6 cts. per yd. per minute with 5 yds. hauled per train.

It is assumed that 5 yds. can be loaded in 2½ minutes in fair digging, exclusive of running time to dump, making the cost 4 cts. per yard. The estimated total cost is, therefore: Loading and dumping, 4.0 cts.; leveling embankments, 1.5 cts.; superintendence and water carriers, 1 ct.; interest, depreciation and repairs, 2 cts.; total, 8.5 cts.

To this fixed charge a variable amount is added to cover the lost time running to and from the place of unloading, which variable is taken from the diagram showing running time consumed in making round trip. The interest, depreciation and repairs is based on the supposition that the loading device, spreader, etc., costs $1,000 and loads 10,000 cu. yds. per year, the interest and repairs each being taken at 5% per annum and depreciation at 10% per annum.

If the ditching is being done in bad, wet material, the cost of loading and dumping is supposed to be increased 30%, which would make a uniform increase in the cost per yard of all lengths hauled of 2 cts. per yd. over the cost in fair digging.

As a confirmation of the estimated cost by this method, reference is made to the paper by Mr. Stanley, Roadmaster of the C. R. I. & P. Ry., presented to this association at its meeting in 1903, in which he stated that earth can be handled at an expense of from 8 to 28 cts. per yd., using a Mart ditching machine, and from 6 to 15 cts. per yd. with 500 ft. to 800 ft. haul, by the American Steel Foundry Co.'s machine.

MACHINE DITCHER LOADING A FULL TRAIN.

A somewhat greater shovel crew is required for a machine ditcher of this class than of the class mentioned above, and it is assumed that the shovel crew wages amount to $10 per day, making a total of $32 for train and crew, which, if actually working only 6 hours per day, would be $5.32 per hour, or 9 cts. per minute. It is assumed also that a train hauling 60 yds. can be unloaded in 15 minutes with plow and cable, making the unloading cost practically 2.2 cts. per yd., and that a train hauling 120 yds. can be unloaded in 20 minutes, at a cost of about 1.5 cts. per yd. It is further assumed that it requires 1½ minutes to load 1 cu. yd. in fair digging, which would make the cost per yard 15 cts. for loading. The estimated cost, therefore, with 120 yds. loaded per train, is as follows: Loading cars, 15 cts.; unloading cars, 1.5 cts.; switching, 1 ct.; leveling embankments, 1.5 cts.; superintendence and water carriers, 1 ct.; interest, depreciation and repairs, 2 cts.; total, 22 cts.

The cost for interest, depreciation and repairs is based on an original cost of $2,000 for the machine ditcher, and the supposition that 20,000 yds. per year will be handled. In case only 60 yds. is handled per train instead of 120 yds., the cost of unloading will be 2.2 cts. instead of 1.5 cts., all other items being the same, which would make a total cost per yard of 22.7 cts. In case the material excavated is wet and very hard to handle, it is assumed that the cost of actual loading will be increased 30% over the above figures, equaling 4.5 cts. per yd. additional.

In confirmation of the above estimates, the following statement of the actual cost of ditching on the Illinois Division of the B. & O. S. W. Ry. with a Mahoney ditching machine during May and June, 1904, is given:

	May.	June.
Total days worked	10	10.5
Total yards load and unload	1,245	1,245
Ave. haul	6	1.75
Total cost loading	$241.67	$274.88
Total cost unloading	55.66	57.64
Cost per cu. yd. loading	19.4 cts.	22.0 cts.
Cost per cu. yd. unloading	4.5 cts.	4.6 cts.
Total cost per cu. yd.	23.9 cts.	26.6 cts.
Total delays	32.h. 10m.	23h. 10m.

In the three diagrams the cost of work trains is taken at $22 per day; six working hours outside of delays; wages of laborers are taken at 15 cts. per hour. The diagrams were prepared by Mr. V. K. Hendricks, Assistant to the Engineer of Maintenance of Way, Baltimore & Ohio Ry., who was a member of the committee, and has kindly furnished us with copies of the diagrams from which our cuts are prepared. The third diagram, Fig. 3, shows the estimated time for a work train to make a round trip to and from the place of unloading, exclusive of time consumed in unloading. This last diagram is accompanied by a table showing the cost per yard for hauling, assuming that the rate per minute for the entire crew with train is based on actual working time, being but six hours per day. The cost of train, hours of actual work and wages of laborers are the same as for the first two diagrams. This table we have rearranged as follows:

Table of Cost per Cubic Yard of Hauling Material in Railway Ditching.

—Work train with 120 yds. and—						Machine ditcher (unloaded by plow).			
100 men.		50 men.		20 men.		120 yds		5 yds.	
Haul ft.	Cost cts.	Haul ft.	Cost cts.	Haul ft.	Cost cts.	Haul ft.	Cost cts.	Haul ft.	Cost cts.
200	1	500	1	500	0.6	2,600	1	200	4
						miles.			
500	2	1,500	2	1,600	1.2	1.60	2	500	8
1,000	3	2,700	3	3,200	1.8	3.30	3	1,000	12
1,600	4	4,500	4	5,000	2.4	5.54	4	1,600	16
2,300	5	6,300	5	7,400	3.0	7.76	5	2,300	20
		miles.							
3,100	6	1.65	6	....	...	10.00	6	3,100	24
4,000	7	2.15	7	....	...	12.22	7	4,000	28
5,000	8	2.70	8	....	...	14.45	8	5,000	32
6,000	9	3.36	9	....	...	....	..	6,000	36
7,300	10	4.07	10	....	...	....	..	7,400	40
miles.									
1.67	11	4.82	11	....	...	....	..	....	..
1.95	12	5.50	12	....	...	....	..	....	..
2.25	13	6.30	13	....	...	....	..	....	..
2.58	14	....	..	....	...	....	..	....	..
2.95	15	....	..	....	...	....	..	....	..
3.30	16	....	..	....	...	....	..	....	..
3.71	17	....	..	....	...	....	..	....	..

The first two sets of figures, for 100 men and 50 men, show a uniform increase up to 27 cts. for 11.3 miles for the former, and 11 cts. for 8.12 miles for the latter. The two last sets of figures, for the machine ditcher give the cost for 120 yds. and 5 yds. of material per train; while with the work train all trains are taken as having 120 yds.

ANNUAL CONVENTION OF THE ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.

The fourteenth convention of this flourishing association was held at Chicago, Oct. 18 to 20, the headquarters being at the Sherman House. It was one of the most successful meetings in the history of the association. The first meeting, on Oct. 18, was opened with prayer, as usual, by Mr. J. H. Cummin (L. I. Ry.); an address of welcome on behalf of the city was delivered by Mr. Taylor, of the city attorney's office, who evidently took it for granted that this was a labor organization, a mistake which rather called attention to the absurdity of these perfunctory addresses by local officials. A short speech was made by the President, Mr. Arthur Montzheimer (E. J. & E. Ry.). The report of the Secretary, Mr. S. F. Patterson (Concord, N. H.) showed a membership of about 300 (and nearly 100 new members were elected during the meeting), and the report of the Treasurer, Mr. C. P. Austin (B. & Me. Ry.) showed a balance of $632.

In accordance with the practice of this association, the reports of the previous convention (1903) were taken up for discussion, but all were passed without remark except that relative to the camber of track on bridge floors: it was the general opinion that the camber should be made equal to the deflection under load.

The new reports were then taken up for consideration:

TRAVELERS FOR ERECTING STEEL BRIDGES.

The report of this committee, presented by Mr. G. W. Smith, of the American Bridge Co., showed that out of lines aggregating 90,000 miles of railway, 55,000 miles represent companies which have adopted the policy of erecting bridges by their own men and equipment, while 30,000 miles represent companies which have this work done by contract. Some companies limit their own work to plate girders, or even to short plate girders, but 35,000 miles represented companies which erect all their own steel bridges.

The use of the derrick car is quite generally advocated, but the extent to which it is used is varied according to circumstances. The Chicago & Northwestern Ry., the Illinois Central Ry. and the Chicago, Burlington & Quincy Ry., representing approximately 15,000 miles of line, have practically adopted the derrick car as the best equipment for erection of not only girder bridges, but through truss bridges as well.

As to the comparative merits of derrick cars and through travelers, the following is a summary of the points which have been given consideration.

1. Adaptability.—Years of experience have shown the overhead traveler to be perfectly adapted to the erection of through and deck bridges. Its general type is well

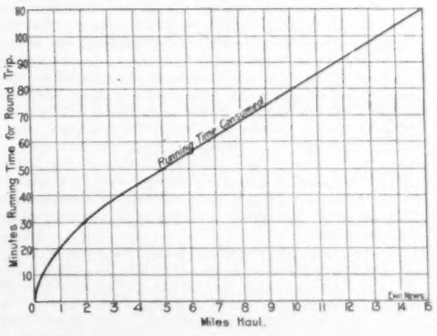


Fig. 3. Diagram of Estimated Time for Work Train to Make Round Trip to and from Place of Unloading; Exclusive of Time Consumed in Unloading.

(Wages, 15 cts. per hour; train and train crew, $22 per day.)

known and simple. It is generally conceded, however, that the derrick car is better fitted for girder bridges.

2. Interference with Traffic.—It is claimed by the advocates of the overhead traveler that this type of rig interferes less with traffic, and is, therefore, preferable for use on lines where trains are frequent. A derrick car, in order to meet the requirements placed upon it, must be self-propelling, and if the turnout has been constructed in close proximity with the bridge, the interruption to traffic should not be much, if any, greater than that oc-

casioned by erection with an overhead traveler. A self-propelling derrick car will, in many cases, take the place of a work train and result in less interference to traffic for that reason.

3. Cost of Preliminary Preparations.—The additional cost in case of an overhead traveler is represented by the extra width of falsework to provide runway for the traveler, and by the cost of erecting and taking down the rig. The extra cost in case of derrick car consists of the provision of spur track at the site for the use of the car.

4. Economy in Operation.—In the erection of girder bridges and trestles a derrick car is by far the cheapest form of rig to be used; and for the erection of truss bridges a derrick car is, to say the least, no more expensive in operation than an overhead traveler.

5. Permanent Investment.—As a permanent investment the overhead traveler is much less than the derrick car, but the derrick car can be used in so many other ways when it is not engaged in the erection of bridges that it is found by those who have used it to be a most valuable tool to have in the department.

G. W. Smith, Moses Burpee, George J. Bishop, A. O. Cunningham, J. C. Hain, I. F. Stern.

In opening the discussion, Mr. Reid (L. S. & M. S. Ry.) stated that he uses the 60-ton wrecking cars of the motive-power department for this work. On double track, he runs empty cars upon one track, removes the girders of the other track by the wrecking cranes, and sets them on the cars, which are hauled away. The cars with the new girders are then run in on the same track, and the girders swung into place. As to this work of renewing old structures, one member said that it was his practice to erect the new span alongside the old one and then to roll the latter aside and roll the former into place, thus breaking the track for only a short time. The cost for crane and crew is about $2 per ton of steel erected, while the total cost of erection of plate girder bridges is $5 per ton. Mr. Eggleston (Erie Ry.) prefers stirrups and 1¾ or 2-in. rods to the use of chains in handling girders. Mr. Steffens (N. Y. Central Ry.) spoke of the use of wrecking cranes in handling 120-ft. girders in bridge renewals on the New York, West Shore & Buffalo Ry. Mr. Killam said that in work of this kind on the Intercolonial Ry. he has frequently floated the spans into place; on short spans, he crowds the old girders together to make room for setting the new ones. Mr. Alexander described the erection of four deck truss spans on the cantilever system on the Bangor & Aroostook Ry., each truss acting as the anchor span for the next one.

CARE OF TRESTLES WHEN BEING FILLED.

1. In filling high timber trestles, breakages of horizontal timbers are unavoidable, and points where posts are not in direct contact with sills and caps are subject to the same conditions, and will also give way under added tons of filling material. Under a heavy fill it is safe to assume that the posts and portions of longitudinal timbers, with the actual bearings of caps and sills in this vertical line of posts, are the only timbers not distorted and rendered worthless by the weight and settling of material in the fill. It should be borne in mind that the vertical timbers and, more strictly speaking, the plumb posts, are the only supporting timbers unaffected by the pressure of the fills, as batter posts are affected in proportion to their inclination from a vertical line. To insure stability in the structure, the best practice is to cut off all horizontal timbers when the filling reaches a height so that they can be eliminated, as they would then be of no value in sustaining a vertical position of the bents, which (if filling is carried up evenly) would be insured by the filling around the bent, and their use would only tend to throw the sill of the next bent above from its natural bearing.

2. The precaution of getting supporting posts in vertical line before filling is a necessary one, and more especially in the heavier fills, as the filling of trestles (say 20 ft. in height or less, single deck) is much simpler. A trestle sufficiently rigid for carrying trains is all right for resisting any pressure that could be exerted against it in filling, and a pile bent has the advantage of having no surface exposed to vertical pressure, which would be the reverse where frame bents are used supported by blocking, which bearing surface would be increased where ground is yielding and the tendency to settle would be increased accordingly.

3. The best results are obtained by carrying up the filling level, and in this way preventing slipping, which would result in a lateral pressure and consequent displacing of bents or breaking of vertical timbers. Should such manner of filling for any reason not be practical or expedient, the trestle would be kept in better position by taking off sway-braces, which would tend to obstruct the natural settlement of the filling; and the least resistance presented by the structure to the natural movement of the filling material will give best results in maintaining same during the filling period.

4. The general practice is to remove ties, stringers and guard rails, leaving the caps to rot out in the fill. The caps are worth saving and are easily removed, and a firmer and better job results from the removal of the caps while ground is loose, and the job is then permanently finished up. Therefore it is preferable to remove the caps along with the other timbers.

5. As to the best time for removal of these timbers, it is apparent that change must be made when frost is out of the ground, and change should be made also when dirt is dry and not in a rainy season. The best time is during summer months and not so close to the freezing-up season as to have any great amount of settlement occur. After that time, however, in low fills where the settling is slight, there are points of advantage in getting timbers out, as they can catch fire and cause possible trouble. If they break, there is no chance to detect it until it could be observed in surface of track, and such a filled-in bridge is not as easy to hold in surface and line as when the track is on the bank.

6. Where practicable, it is an economical plan to grade in as much by team and scraper from below as can be conveniently reached, and such filling is pretty well packed as it is made. This appears to be the usual practice, but in high fills it is of course, necessary to fill in the greater bulk from the top.

A considerable part of the discussion related to experiences in the filling of sink-holes; in one case, the filling caused the gravel to rise on either side of the trestle and work was stopped until material had been dumped on these ridges, after which the bank was completed without trouble. Alternate ties are sometimes taken out to allow the filling to fall more readily through the floor. Few speakers removed any timber below the stringers, but it was the general opinion that after the first settlement it was much easier to keep the track in line and surface on the bank than if left to be carried on the embedded timbers. Mr. Alexander (Bangor & Aroostook Ry.) said that he had put in a gas engine and pump and wetted down the filling as it was deposited, with the result that there was practically no settlement; in such a case he would remove the stringers at once, but with ordinary dry filling he would leave the stringers in place for a time.

STEAM HAMMERS OR DROP HAMMERS FOR PILE DRIVERS.

MAJORITY REPORT.—The steam hammer is the best type of hammer for all kinds of pile driving, and when used with a bonnet makes pile driving a comparatively easy job. Piles can be driven without injury to the pile in almost any kind of earth with a steam hammer, where it would be rent from head to point by a drop hammer. The pile is held much more firmly under the steam hammer, and is guided home in much better fashion than can be accomplished with the drop hammer; besides there is not the injurious strain upon car and machinery that is felt from the drop hammer. The cost of maintenance is much less for the steam than for the drop hammer, and the cost of driving piles is also much less. The first cost of the steam hammer is, of course, much greater, but it is a good investment notwithstanding.

MINORITY REPORT.—For very hard driving, such as hard clay and hard pan, and in some cases for very soft driving, the heavy drop hammer is the best, as it has enough energy in its blow to break the hold of the pile in the earth and force it down, where many times a steam hammer will not do this. I have seen a steam hammer bang away on the tops of piles until they were completely worn off and got so hot that they even took fire, but still would not go down. A drop hammer is more convenient to handle than a steam hammer in a road driver, as the steam hammers are so heavy that the driver needs lots of counterweight to balance them when it is swung. Also, they are so long that very long leaders must be used in order to get piles under them, and with a heavy hammer at the top of the long leaders the machine is very likely to tip over on the track with much elevation or a track which is very much out of surface, as the tracks frequently are where work is being done. If I could only have one hammer for general railway pile driving I would prefer a drop hammer to a steam hammer, as I think the work in general can be done cheaper, everything considered, with a drop hammer than with a steam hammer. Of course, a steam hammer is very desirable in some kinds of work, but for a single hammer I would prefer a drop hammer. In regard to using a bonnet, this can be used fully as well with a drop hammer, and will take up proportionately less of the energy of the blow of a drop hammer than of a steam hammer.

A letter from Mr. A. S. Markley (C. & E. Ill. Ry.) pointed out that a steam hammer is as effective at the top of the leads as at any other point, and stated that four piles could be driven by the steam hammer while two are being driven with a drop hammer. One member cited a case where a 50-ft. test pile was driven in 35 minutes by a drop hammer, but afterwards the 50-ft. foundation piles were driven in 4 minutes each by a steam hammer. Another member thought the steam hammer too heavy for railway work, and the general opinion seemed to favor the drop hammer, doubtless on account of the much greater experience with this. Mr. Finley (C. & N. W. Ry.) considered that the steam hammer is more efficient and more scientific, and that it will come into much more extended use in railway work. The method of driving must depend very largely upon the nature of the soil.

DOORS FOR FREIGHT HOUSES AND ENGINE HOUSES.

Freight House Doors.—The door in common use is a wooden, panel door, moving horizontally, hung by attaching two wheels to top of door to run on track fastened to the wall; when open the door is boxed in. This kind of door gives good satisfaction and cost of repairs is small. When it is desirable to use doors with a vertical movement, they will be found satisfactory when hung with large sheaves (10 to 14 ins. diameter) and running cable, with counterweights made for the purpose. The door with vertical movement has the advantage of not being interfered with by snow and sleet so much as the door with the horizontal movement. On the track side of the freight house the vertical-moving door will be found best, as this will allow the wall to be practically all doors and will fit any length of car.

Roundhouse Doors.—The wood panel, square-top door, with three or four hinges, with as little glass as possible, is the best. The doors should have good clearance at the bottom (not less than 2 ins), as most roundhouse doors are sprung and warped out of shape by crowding them over the ice and heaved track in winter.

It was explained that on the Boston & Maine Ry. the freight houses are lined with the posts set back 5 ft. and the doors hung from the line of the eaves. In this way the difficulty of getting a car door obstructed by a post is avoided. A good arrangement is for the lower half of the door to slide vertically behind the upper half, and then both parts swing by a horizontal position. Doors folding horizontally were approved, but the high cost due to their being patented appliances, was mentioned as an objection at the present time. Doors of roundhouses give considerable trouble by getting out of shape so as not to close or fasten properly. Mr. Shane has doors swinging inward, but it was thought that few railways would want to build the house large enough for this. Mr. McGonagle spoke of using doors reaching only to within 10 ins. of the ground, and placing a heavy timber, notched for the rails, behind them; Mr. Reid thought that a hinged bottom plank on the door would be more convenient.

PRESERVING TIMBER AND PILES.

This report consisted largely of a summary of processes used. It was pointed out, however, that while the failing source of timber supply will make the preservative treatment of timber more necessary every year, yet it cannot be expected that the railways (which are the largest users) will view the matter from the standpoint of a national necessity as long as the present prices of lumber continue.

Replies received show that less than 2% of the railways of North America have used treated timber. Of these the largest user is the Louisville & Nashville Ry. Through the courtesy of Mr. R. Montfort, Chief Engineer, the following data were furnished: On the New Orleans & Mobile Division there are 25 pile trestles, all of creosoted material, length 21,480 ft., and 7 iron and steel bridges, 5,965 ft., supported on creosoted piles. The former were constructed in 1878; the piers supporting the latter in 1876. On the Pensacola & Atlantic Division there are 62 pile trestles, 30,293 ft. Three of these (12,468 ft.) are creosoted. The other structures on this division are three combination bridges, 405 ft. total length, and four iron bridges, 672 ft. total length, supported on creosoted piles driven in 1882. The piles and timber in these trestles were treated by the usual creosoting process, and were given as much as 20 lbs. of creosote per cu. ft. The piles are still sound, and good for many years to come. Untreated timber in these waters would stand about seven years against decay, and about six months against the attacks of the teredo.

The time has evidently not yet arrived when beyond patriotic reasons the necessity for use of preservative processes is apparent. The price of untreated timber ranges from $10 to $14 for cedar, cypress, white oak, and tamarack, to $25 and $28 for yellow pine, according to locality where purchased.

Several roads, one prominent Eastern railway included, are using creosoted timber above low water line for pier construction. The use of treated timber will undoubtedly become more prevalent in this form of structure, where the inaccessibility of substructure and inconvenience due

to disturbance of traffic render desirable less frequent renewals.

For convenience in estimating, the following data may be of value: The weight of one gallon of dead oil is 8.8 lbs. The cost about 7 cts. per gallon. Cost of creosoting on large scale about 5 cts. per cu. ft. of timber treated. For average conditions, 12 lbs. of creosote per cu. ft. may be used. This is about the maximum that yellow pine will absorb. For piling and submerged work, the amount should be increased to a maximum of about 22 lbs. per cu. ft. for protection against the teredo. A rough rule for convenience in estimating will be to use a cost of 1 to 1½ cts. per lb. of creosote in place.

The discussion drifted from the subject and related largely to experiences with piles of different kinds. The question was asked whether the sap wood of treated pine timbers and piles is any stronger than that of untreated timber, the increase in durability being admitted, but the increase in strength considered doubtful, and sap wood is ordinarily of little value as far as strength is concerned. One member had used a preservative applied to bridge floor timbers and ties as a paint, and thought it had given results sufficient to pay for the cost. Another member, however, thought it of very little value to use preservatives applied in this way.

PROTECTION OF OVERHEAD METALLIC STRUCTURES FROM GASES AND BLASTS OF LOCOMOTIVES.

This report, which we publish separately, consisted of individual statements of opinion. In the discussion, Mr. Killam (Intercolonial Ry.) favored iron-oxide paints, and described his method of testing paints by using them on iron plates which are hung from a bridge where they are subjected to salt water spray. Mr. Steffens (N. Y. Cen. Ry.) thought a ⅞-in. plank sheathing would protect only against the action of the blast, as the gas and steam would find its way through the joints. Mr. Reid (L. S. & M. S. Ry.) has used 1 in. of concrete on expended metal, but finds it to fall off in patches. Portland cement paint has flaked off, but asphalt paint is better, especially if applied hot upon hot metal. He doubted whether concrete could be made to adhere permanently, as the vibration due to traffic will tend to loosen it from the iron.

BLANK FORMS FOR RECORDS OF BUILDINGS, WATER TANKS, ETC.

This committee presented a set of the forms used by the Chicago & Northwestern Ry. and other lines, with comments and suggestions from various members. The blanks of the C. & N. W. Ry. are 10 × 16½ ins., or double the ordinary business letter head, so that they can be folded and filed in the ordinary letter file, or bound in book form, as desired. They are printed on thin paper and blue-print copies can be made for the use of officials who may have occasion to refer to records of this kind. There was no discussion of the report.

BEST FORM OF ENGINE HOUSE.

This report contained summaries of individual replies to a circular letter of enquiry, and also extracts from articles on "Circular and Rectangular Engine Houses" in Engineering News of March 3, 1904. Most of the individual replies favored the circular form, as is natural, this being most generally used, but several engine houses of the rectangular plan have recently been built, including the three of the Terminal Railroad Association of St. Louis, illustrated in our issue of Sept. 29. A letter from Mr. Geo. P. Nichols, of Chicago, which was appended to the report, estimated the cost of the rectangular house as slightly greater than that of the circular house of equal capacity, but in the first case all operations are under roof, while in the second case the turntable and space between the table and the house are uncovered. Shortly after the publication of Mr. Nichols' paper on rectangular engine houses (Engineering News, March 3, 1904), the Pere Marquette Ry. adopted this form for houses at Grand Rapids, Mich., and St. Thomas, Canada. Here, however, the engine house is on one side of the transfer table and the repair shop on the opposite side. The committee summarized the advantages of the two forms of engine houses as follows:

RECTANGULAR ENGINE HOUSES.—1. Economy of ground space occupied.

2. Uniform room at front and rear of engines while in house, making it easier to work on engines.

3. Economy in construction of walls, floor and possibly roof.

4. Economy in piping for heating, water, steam and lighting.

5. Opportunities for pit drainage, which could be straight, open drain under transfer table.

6. Erecting shop, machine and washout section can be in connection with engine house, and either can be utilized as circumstances may require, thus concentrating buildings, men and tools.

7. Only one, or perhaps two, outside doors required; less heating and repairs.

8. More open to inspection and more uniform light.

9. No trouble with turntable radial tracks in winter.

10. Less trouble with snow and ice in turntable pits and around engine house doors.

CIRCULAR ENGINE HOUSES.—1. Close proximity to turntable, making the despatching of engines a matter of very little delay.

2. The handling of one engine between house and turntable without any relation to any other part of the house.

3. Saving of expense of transfer table and cost of operating.

4. Economy of ground space when track approaches and outside turntable for rectangular engine houses are considered.

Mr. A. S. Markley (C. & E. Ill. Ry.) favored the rectangular plan, with stalls on each side of the transfer table, and only one engine to each stall. He has a new roundhouse for 54 engines which is already too small, but the only way to increase the capacity is to find a new site for an additional house. With a rectangular house, extensions can be made as desired. Mr. Killam thought there would be more engine movements, and described an arrangement of roundhouses with connecting tracks. The question of turning the engines, of course, came up, and the use of turntables and Y-tracks in the yard were suggested. Mr. Finley (C. & N. W. Ry.) thought there would be little difficulty in making a transfer table which could be revolved at the end of the pit. A combination turntable and transfer table is in use at a French passenger terminal.

THE USE OF CONCRETE UNDER BRIDGE BED-PLATES AND TURNTABLES.

A very brief report was presented, showing that concrete can be successfully used in such cases. Mr. Reid (L. S. & M. S. Ry.) uses concrete of 1 Portland cement, 3 gravel and 6 limestone; he considered good concrete better than 75 per cent. of ordinary stone masonry. Failures are generally due to poor concrete; unskilled labor may be used, but should certainly be under the supervision of skilled and experienced foremen and inspectors. Some members spoke of repairing old broken masonry piers, etc., with an envelope or casing of concrete.

FILLING ICE HOUSES AND CONVEYING ICE TO REFRIGERATOR CARS.

This was the subject of another brief report, favoring the system of distributing the ice in luggers or trucks. Mr. Shane thought large crushers should be used, and mechanical conveyors supplying pockets, as at coaling stations. Then when notice is sent to the ice house that a train of so many cars is to be iced, the pockets can be filled in readiness. Mr. A. S. Markley thought that the varying lengths of cars would interfere with such a plan.

FILLING TRACK TANKS AUTOMATICALLY.

This short report favored steam pumps in preference to others, as the boiler can supply steam for heating the water in winter. It was suggested that the automatic valve caused the speed of filling to reduce as the tank fills, so that where two or three trains follow at short intervals they may not get enough water. Mr. Steffens said that there had been no such trouble on the New York Central Ry.

A paper on "Cleanliness of Station Grounds and Buildings" was read by Mr. J. H. Markley (T. P. & W. Ry.), and an address on the development of bridge design was given by Mr. W. H. Finley (Prin. Asst. Eng.; C. & N. W. Ry.).

THE EVOLUTION OF RAILWAY BRIDGE BUILDING.

1. Timber Stringer Bridges.—The bolster or corbel type of construction has been practically abandoned, as well as mortise and tenon connections; the use of proper longitudinal bracing is now generally being rendered necessary by the stresses due to modern braking equipment.

2. Timber Truss Bridges.—The Howe truss represents the survival of the fittest, and many of these old bridges have been removed while in good condition, owing to the increase in weight of rolling stock.

3. Plate Girders.—Modern improvements are the use of heavier web plates, more scientific arrangement of stiffeners, and a top chord arrangement without cover plates, which avoids the necessity of boxing the ties for these plates. Improvements in methods of manufacture have had something to do with these improvements in design.

4. Truss Bridges.—The pin-connected type, which is distinctively American, has gradually been reduced to the Pratt truss, and American bridges of this type are now in use in various parts of the world, owing largely to the ease of erection. Other styles of trusses usually designed to save weight and cost, have become practically obsolete. Secondary stresses were also little understood by early designers. Trusses are now characterized by deep floors, large pins, heavier metal and rigid lateral bracing. Segmental rollers for expansion bearings were in many cases unsatisfactory, as they would not return to position, and the shoes simply slid upon them. This had been remedied by pruning teeth on the roller and shoe, so that the former is bound to move. End bearings without means of distributing the load resulted in shattered masonry of the bridge seats, which trouble is now avoided by the use of pin bearings.

5. Riveted Lattice Trusses.—The earlier bridges suffered from unskilful design, especially in lack of attention to the neutral axis of members meeting at a joint. This was most notable at the hip joints, and resulted in oscillation. The web members were also too far apart, floors too shallow, and floor beam connections faulty. Modern bridges of this type are now extensively used on Western railways.

6. Steel Viaducts.—The improvements are mainly in heavier construction, with rigid riveted bracing instead of adjustable rod bracing.

7. Masonry Arches.—There are many fine modern examples of stone arch structures. Their competitor is the concrete and reinforced-concrete arch, but this is yet in the development stage. Many designers are making the mistake made by designers of early truss bridges in aiming at a minimum of material and cost, rather than at stability and ultimate economy.

8. Solid Bridge Floors.—Ballasted floors are coming into use for short spans, and in some cases even for long truss spans. They are also being used for timber trestles. Their use reduces the cost of maintenance of the structure and of the track, both on the bridge and at its ends.

OFFICERS.

Officers were elected as follows: President, C. A. Lichty; Vice-Presidents, J. B. Sheldon, J. H. Markley, R. H. Reid and R. C. Sattley; Treasurer, C. P. Austin; Secretary, S. F. Patterson, Concord, N. H. The next meeting will be held at Pittsburg, Pa., in October, 1905.

ENTERTAINMENTS.

The entertainments provided by the local committee included a visit to the South Chicago steel works and cement plant of the Illinois Steel Co., a trip on the Chicago River to see the various types of drawbridges, a visit to the tunnel system and automatic telephone exchange of the Illinois Tunnel Co., and a special entertainment at the hotel one evening. After the close of the convention a number of the party went to St. Louis, transportation and special accommodation being provided by courtesy of the Chicago & Eastern Illinois Ry.

COAGULATION PLANT AT THE SETTLING BASINS AT ST. LOUIS, MO.

By E. E. Wall.*

The new process of clarifying and purifying the Mississippi River water at St. Louis has advanced to a point where it can no longer be looked upon merely as an experiment, but must be considered as indicative of the probability that there will be designed a cheap and simple method of producing clear, potable water from the more or less polluted and silt-bearing streams of this country.

The Mississippi River water at St. Louis contains throughout the year from 60 to 6,000 parts per 1,000,000 of suspended matter, from 30 to 90 parts per 1,000,000 of sulphate of lime, and from 60 to 200 per 1,000,000 of carbonates of lime and magnesia, besides small quantities of iron and silica in solution. The number of bacteria varies from 1,000 to 100,000 per cu. cm.

The plan of simple sedimentation is impracticable because of the immense area of settling basins which would be required, as well as for the fact that at certain seasons of the year no reasonable length of time would be sufficient for the suspended matter to settle out, even with the

*Principal Assistant Engineer, Water-Works Extension.

water perfectly still and undisturbed. Plain sedimentation would not remove the discoloration from the water nor would it reduce the number of bacteria sufficiently to be considered a purifying process.

The popular prejudice against the use of alum in clarifying the water supply of St. Louis is so intense that it is very doubtful if alum could be used—no matter how excellent the results obtained, or how conclusively the facts might warrant its use.

In October, 1903, experiments were begun in the laboratory with the view of using lime and ferrous sulphate as clarifying agents. These chemicals had been used at Quincy, Ill., and at Lorain, O., in connection with mechanical filters, with excellent results. As St. Louis had no filters and neither time nor inclination to build them, it was obvious that a radical departure from the process in use at those places would be necessary. The use and action of lime and iron at Quincy and Lorain is substantially as follows:

Only enough lime is added to the raw water to combine with the free carbonic acid (CO_2) in the water and also to replace the iron in the ferrous sulphate ($FeSO_4$) when it is added, forming carbonate of lime ($CaCO_3$) and sulphate of lime ($CaSO_4$), leaving the iron to form a coagulant of ferrous hydrate which oxidizes to ferric hydrate and is caught on the filters together with the suspended matter entangled with it. Only a comparatively small amount of lime is added, while the amount of ferrous sulphate varies from one to three grains per gallon. The effect of this process is to add to the hardness of the water the amount of sulphate of lime produced by the reaction of the lime on the ferrous sulphate and on the free carbonic acid. The chemicals are added for coagulating purposes only, and the purification part of the process is dependent solely upon the filters. The lime is added in the form of lime water in measured quantities and the iron dissolved and added as a solution of constant strength.

With the amount of water pumped daily at St. Louis, from 60,000,000 to 120,000,000 gallons, this method of introducing lime and iron seemed hardly practicable, as it would require enormous storage capacity, especially for lime water. It would also be necessary to install additional machinery to manufacture the lime water. After a great deal of study and experiment, a temporary coagulating plant was built and put in service with excellent results from the start.

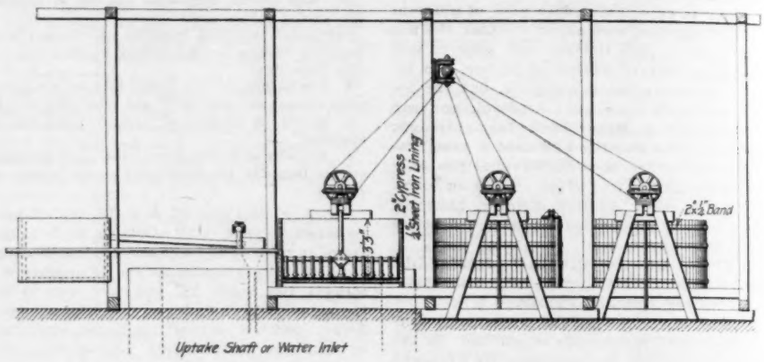
This plant has been installed hurriedly and had to be designed to be used in conjunction with the water-works as built, and had to fit in and be successfully operated with a set of changes already made for a different scheme, and fully described in Engineering News of Nov. 26, 1903.

The coagulating house is a frame building situated on the river bank over the uptake shaft which connects the river and inshore tunnels. This building is 48 × 144 ft., and has storage bins for sulphate of iron in one end, and bins for lime in the other. The scales and mixing tanks are in the central part of the shed.

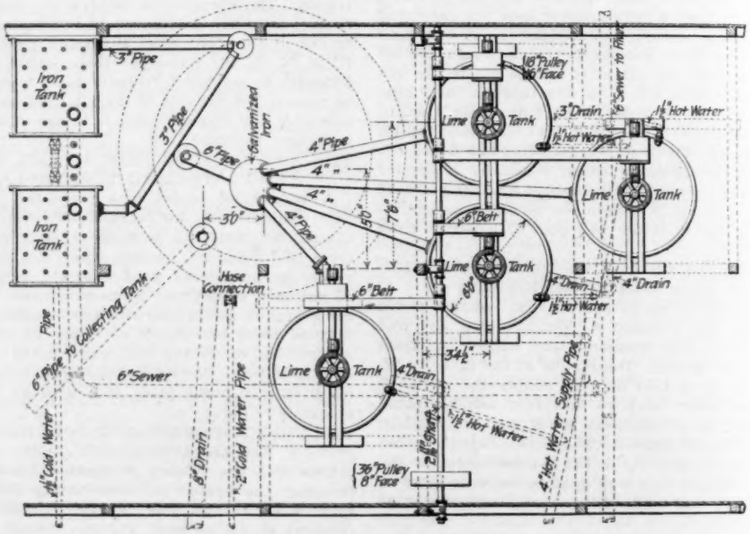
As shown on the accompanying plan, there are four lime tanks, 6 ft. in diameter and 3 ft. deep, each being designed to handle a maximum quantity of 1,800 lbs. of quicklime per hour, producing milk of lime carrying from 7,000 to 8,000 grains of lime per gallon. The strength of the milk of lime varies with the quantity of water being treated, as well as the varying amount of water supplied to the tanks. It is not necessary that the solution should be of constant strength, since the lime is thrown into the tanks at five-minute intervals, the proper amount for each charge being weighed, and varying according to the number of grains of lime per gallon required to be added to the raw water.

The lime tanks are continually supplied with hot water at a temperature of about 120°F., because lime will slake only very slowly in cold water. It begins to slake at once in water at 120°F., and a charge will be completely slaked in fifteen minutes in the tanks. The lime is constantly stirred by revolving rakes with spring steel teeth, details of which are shown in the accompanying illustration. The tanks are made of wood lined with steel plates, with outlet pipes 2 ft. above the bottom. The milk of lime flows through 4-in. outlet pipes to a 6-in. pipe leading to a small collecting tank, from which it is pumped by a centrifugal pump, electrically driven, through a 6-in. cast iron pipe to the delivery well, shown on the plan, where it mixes with the raw water from the low service pumps.

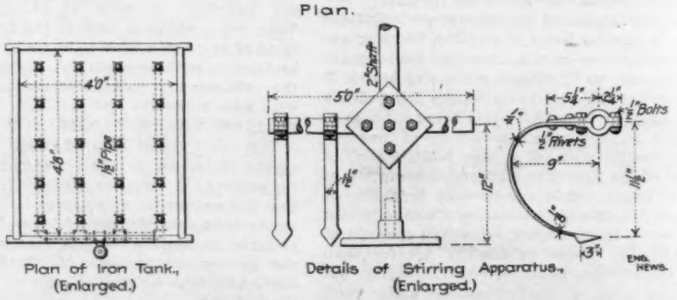
The collecting tank is 3 × 6 ft. × 3 ft., and has a compartment 18 × 24 ins., boxed around the suction pipe of the centrifugal pump. The milk of lime flows into this compartment, the tank proper



Sectional Elevation.



Plan.



Plan of Iron Tank, (Enlarged.)

Details of Stirring Apparatus, (Enlarged.)

DETAILS OF COAGULATION PLANT AT THE ST. LOUIS SETTLING BASINS.

being supplied and kept at a constant height by a 4-in. pipe connected to Basin No. 1. This pipe delivers a maximum amount of 140 gallons per minute of cold water which serves to dilute and cool the milk of lime. The small compartment around the suction pipe has openings at the bottom to allow free ingress to the cold water so that there shall be no danger of the pump emptying the compartment. In case of a stoppage of the pump the collecting tank has an overflow into the uptake shaft so that the milk of lime is then introduced into the raw water at that point and passes through the low service pumps. This is objectionable and is only to be used in case of emergency.

There are two tanks for iron 4 × 5 ft. [illegible] deep, supplied with cold water, introduced [illegible] bottom of the tanks, through a system of 2 [illegible] zles, each having four 1-16-in. openings [illegible] sides, so as to produce a network of small [illegible] zontal streams over the bottom of the tank. [illegible] ferrous sulphate is put into the tanks in [illegible] tically the same manner as is the lime. It [illegible] dissolves, and overflows from the tanks into [illegible] leading down the uptake shaft into the tu[illegible]

No stirring apparatus is needed in the iron tanks and only cold water is used. Each tank will dissolve 1,800 lbs. of sulphate of iron per hour.

It is evident that by this process a certain definite amount of both lime and iron can be added to the raw water at a constant and practically unvarying rate, without any regard to the quantity of water used in making the solutions, provided always that enough water is supplied to dissolve the iron or to slake the lime as rapidly as it is thrown into the tanks. An excess of water will have no practical effect on the result.

The quantity of lime added to the water supply

TABLE I.—Some Weekly Sanitary Chemical Analyses of River and Treated Water at St. Louis, Mo.*

Date, 1904.	Sample.	Parts per 1,000,000. Solids.— Dissolved.	Suspended.	Total.	—Ammonia.— Free.	Alb.	Nitrites.	Nitrates.
April 1..	River...	157	2,286	2,443	0.45	1.09	0.02	1.40
"	Treated	150	89	239	0.29	0.33	0.028	1.40
April 15.	River...	192	1,505	1,697	0.188	1.02	0.02	1.10
"	Treated	152	91	243	0.142	0.224	0.035	1.00
May 6...	River...	162	1,435	1,597	0.058	1.11	0.111	0.80
"	Treated	146	78	224	0.028	0.224	0.016	1.00
May 13..	River...	195	1,323	1,518	0.062	0.083	0.008	0.60
"	Treated	157	23	180	0.036	0.017	0.008	0.60
June 3...	River...	200	3,882	4,082	0.124	1.64	0.008	0.60
"	Treated	157	57	214	0.04	0.158	0.007	0.54
July 1....	River...	253	3,640	3,893	0.08	1.750	0.002	0.70
"	Treated	179	49	228	0.042	0.182	0.006	0.70
July 22..	River...	198	1,507	1,705	0.06	0.770	0.004	0.60
"	Treated	147	16	163	0.028	0.178	0.007	0.56
July 29..	River...	223	1,752	1,975	0.064	1.130	0.003	0.70
"	Treated	148	42	190	0.012	0.108	0.005	0.70
Aug. 5...	River...	247	1,448	1,695	0.048	0.690	0.002	0.60
"	Treated	155	38	193	0.016	0.106	0.005	0.60
Aug. 12..	River...	309	1,095	1,404	0.046	0.53	0.002	0.50
"	Treated	194	42	236	0.014	0.116	0.003	0.50
Aug. 19..	River...	280	1,122	1,402	0.042	0.570	0.003	0.46
"	Treated	198	67	265	0.016	0.108	0.003	0.40
Aug. 26..	River...	192	1,486	1,678	0.036	0.94	0.001	0.50
"	Treated	159	34	193	.....	0.108	0.003	0.50

*Made for the local Board of Health by the City Chemist, Walter Bernays, Old City Hall, St. Louis, Mo.

of St. Louis has varied from 4 to 9 grains per gallon, due to the changing condition of the raw water. Sulphate of iron has been added in varying quantity, from ½ to 3 grains per gallon.

The coagulating plant was started on March 22, 1904, and during a period of 147 days from that date to Aug. 15, 1904, 4,275 tons of lime were used: an average of 29.9 tons per day, amounting to an average of less than 5 grains per gallon. During the same period, 1,359 tons of sulphate of iron were used; an average of 9¼ tons per day, or nearly 1½ grains per gallon. The river began rising about March 6, 1904, and remained at a very high stage until July 20, 1904, necessarily requiring heavy amounts of coagulant for clarification. The cost of operating the coagulating plant during this period of 147 days has been approximately $3.2) per 1,000,000 gallons. The average cost per million gallons for the year will probably be much less than this figure, and it is expected to still further reduce the cost in the future by improved machinery, by better methods of handling the chemicals, and by the use of a more flexible system in passing the water through the basins. The installation of the coagulating plant complete has been less than $10,000.

The treated water has not always been as clear as it should have been, owing to defects in mechanical appliances, as well as to inexperience of employees unaccustomed to observe closely or to appreciate the importance of small details. On the whole, the treated water has shown such marked improvement that it is only a question of improving mechanical devices to be able to furnish an unvarying supply of clear and pure water.

On April 1, 1904, the suspended solids in the raw water were reduced from 2,445 to 97.5 parts per 1,000,000 in the treated water; on May 31 the suspended solids were reduced from 1,717 to 25 parts per 1,000,000, and on June 6 from 2,991 to 10 parts per 1,000,000.

The action of the lime on the raw water proceeds along the following lines:

The carbonate of lime in the raw water, which at times amounts to 152 parts per 1,000,000 (about 9 grains per gallon) is held in solution as bicarbonate ($CaH_2(CO_3)_2$). The added lime (CaO) reduces all the bicarbonate to normal carbonate ($CaCO_3$), which is only soluble to a limited extent. All of the remaining normal carbonate is precipitated in an amorphous state, but immediately begins to crystallize and attach itself to the suspended matter, thus aiding in sedimentation. The bicarbonate of magnesia ($MgH_2(CO_3)_2$), in the raw water is changed by the lime into normal carbonate of lime and hydrate of magnesia ($Mg(OH)_2$), which is a coagulant and insoluble and which will settle slowly, but whatever portion of the hydrate of magnesia remains in suspension gradually becomes reconverted into bicarbonate by the action of the carbonic acid gas absorbed from the air, and is then at once taken into solution again. The ferrous sulphate combines with the lime to form ferrous hydrate which oxidizes to ferric hydrate and is precipitated and carried down with the normal carbonate of lime. The calcium sulphate formed by the reaction of the lime and iron enters into solution, slightly increasing the permanent hardness of the water, the total hardness of which is very largely decreased by the precipitation of the carbonates. Tables I. to III. give some of the results obtained by coagulation and sedimentation, as indicated by their respective headings.

During the progress of this work of clarifying the water supply, a great many minor difficulties have been met with, which have served to prevent a uniformity of results, and which will account for the occasional relapse in efficiency of the treatment. In considering the tabulated results of the analyses given above, it should be remembered that the amount of water treated daily during this period has varied from 70,000,000 to 120,000,000 gallons; that the process of clarification has been carried on while changes were being made in the settling basins, often preventing the most advantageous manner of handling the water, that the coagulating plant erected at first as a temporary structure had to be improved and changed to meet new conditions; that the entire distribution system consisting of 700 miles of mains necessarily contained many deposits of mud in low places and at dead ends, which have been slowly washed out by the clear water, locally affecting the supply at the taps; yet in spite of these and other difficulties and drawbacks, the quality and appearance of the water furnished the people of St. Louis has continually improved until at the present writing (Sept. 15, 1904), there is scarcely anything to be desired as to the water itself—and further steps for improvement must be taken mainly in the direction of reducing the cost of the treatment.

TABLE II.—Certain Mineral Constituents and Bacterial Contents of River and Treated Water at St. Louis, Mo.*

1903-4. Date.	Sample.	—Coagulant†— Lime.	Iron.	Parts per 1,000,000 CaSO4	CaCO3	MgCO3	—Solids.— Suspended.	Dissolved.	Alkalinity.	Bacteria per cu. cm.
Oct. 29...	River...	..	..	40.40	.....	.....	.....	.....	.....	.....
Nov. 30...	River...	..	..	38.57	93.80	68.67	.....	.....	.....	.....
Dec. 31...	River...	..	..	86.26	143.36	69.78	.....	.....	.....	.....
Jan. 27...	River...	..	..	55.14	52.86	38.85	.....	.....	.....	.....
Feb. 29...	River...	..	..	67.14	78.20	46.62	.....	.....	.....	.....
April 1....	River...	..	..	45.98	49.82	30.94	2,442.5	.....	98	.....
"	Treated	6	¼	50.78	48.93	9.47	97.5	.....	72	.....
April 30..	River...	..	..	40.41	63.07	28.46	.....	.....	.....	.....
"	Treated	6	1	56.37	36.07	6.23	.....	.....	.....	.....
May 31...	River...	..	..	60.18	45.00	42.80	1,717.3	231.2	134.4	.....
"	Treated	7	2	72.51	0.71	22.72	25.0	168.00	53.2	.....
June 6....	River...	..	..	.....	.....	.....	2,290.8	171.2	.....	4,000
"	Treated	9	3	.....	.....	.....	9.8	141.2	.....	7
June 13..	River...	..	..	.....	.....	.....	.....	.....	.....	22,854
"	Treated	8	1½	.....	.....	.....	.....	.....	.....	None
June 21..	River...	..	..	.....	.....	.....	.....	.....	.....	13,346
"	Treated	7	2	.....	.....	.....	.....	.....	.....	43
June 30..	River...	..	..	63.30	65.40	34.02	3,763.0	206.4	109.2	.....
"	Treated	9	2	63.30	21.48	14 89	32.5	148.0	38.6	.....
July 30...	River...	..	..	55.50	31.80	33.80	1,694.2	200.8	122.0	.....
"	Treated	7	3	76.10	none	7.12	43.6	144.4	42.0	.....
Aug. 31..	River...	..	..	63.98	41.52	36.44	800.3	233.2	.....	.....
"	Treated	5	1	51.06	18.40	7.56	15.5	150.0	.....	.....
Sept. 6....	Treated	5	2	.....	.....	.....	4.8	177.0	.....	.....

*Made in the laboratory of the Water Department by John F. Wixford, Chemist, Water Works Extension, St. Louis, Mo.
†Grains per gallon.

A NEW DESIGN OF DRAWING DESK FOR TWO PERSONS.

A drafting room of the department of civil engineering of the Worcester Polytechnic Institute has recently been equipped with drawing desks of new design. The desks were planned to furnish the students good firm supports for the drawing boards, places for tools while at work and storage for all equipment when work is suspended. The engraving shows how these features have been provided.

The desks are double and allow the use of the department's standard boards, 28 × 42 ins. The size of the top is 3 × 9 ins. × 6 ft., and the distance from floor to top is 3 ft. 2 ins. The partition and shelves are used for holding tools, notes, sketches, etc. There are eight drawers, 15½ × 19 × 6 ins. inside measurement, which may be used by four men for storage when two classes or divisions are accommodated in the same room at different hours. There are spaces for eight drawing boards, and the tee-squares are provided for under the top, as shown.

An Improved Form of Drawing Desk for Two Persons. Worcester Polytechnic Institute, Worcester, Mass.

With the exception of the top, which is of white pine, the desks are built of ash. The frame is made very stiff by the mortise and tenon and bolted joints, the paneling and the cast-iron brackets which are used at the junction of the top with lower work and at the foot rest. As installed at the Institute, each desk is furnished with two electric lamps which are wired through a pipe passing up through the desks in the center, and are supported on adjustable fixtures. The desks were designed by Prof. A. W. French of the civil engineering department, and were built at the shops of the Institute.

TABLE III.—Some Bacterial Analyses of River and Treated Water at St. Louis, Mo.*

Date, 1904.	Sample.	No. colonies.	Per cent. loss.
Apr. 15..	River...	148,000	93.4
"	Treated	9 750	
May 6....	River...	22 500	92.0
"	Treated	1,800	
May 13..	River...	103,500	63.8
"	Treated	37,500	
May 27..	River...	45,800	98.3
"	Treated	750	
June 3...	River...	30,000	88.3
"	Treated	3,500	
June 17.	River...	16,000	96.56
"	Treated	550	
June 24.	River...	33,000	95.15
"	Treated	1,600	
July 15..	River...	26,000	83.46
"	Treated	4,300	

*Made weekly for the Board of Health by the City Bacteriologist, Chas. A. Snodgrass, 1624 Chestnut St., St. Louis, Mo.

DITCHING DREDGE AT COUNCIL BLUFFS, IA.

The city of Council Bluffs, Ia., has recently undertaken the deepening and widening of Indian Creek, which passes through the city and overflows so frequently that it is a cause of considerable expense to the city and the property owners. It is also the outlet for a large amount of sewage.

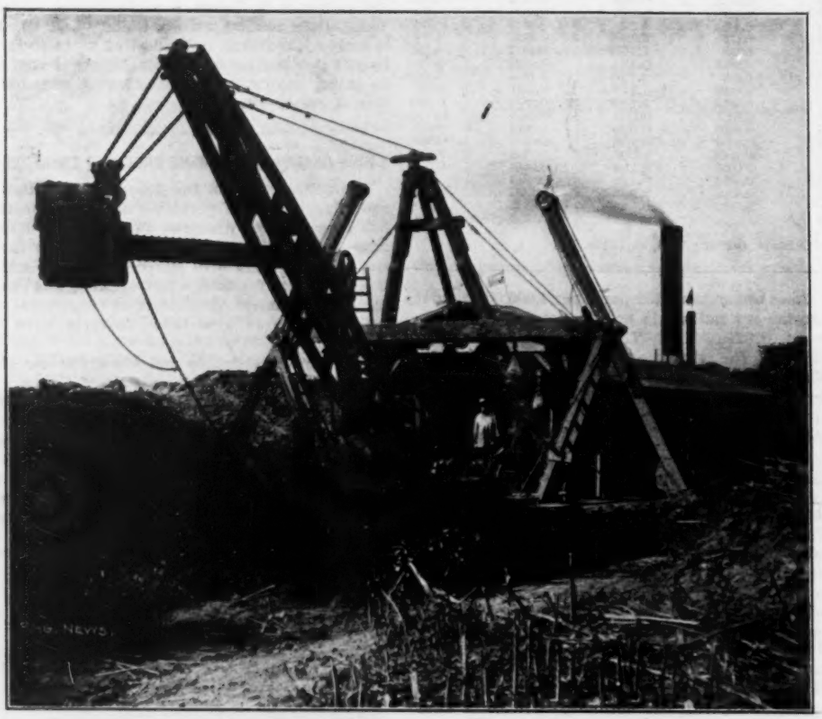


FIG. 1. DITCHING DREDGE FOR THE CITY OF COUNCIL BLUFFS, IA.
Bellefontaine Foundry & Machine Co., Bellefontaine, O., Builder.

The lowest proposal for this work was over 16 cts. per cu. yd., and the City Council decided to reject the bids and purchase a dredge for the work. The contract was given to the Bellefontaine Foundry & Machine Co., of Bellefontaine, O., and the dredge was delivered in August. Fig. 1 is a view of the machine at work. It was guaranteed to excavate 350 to 700 cu. yds. per day of 10 hours, and is said to have made a record of 800 cu. yds. per day. The hull is 16 ft. wide, 50 ft. long and 5 ft. deep, with a draft of about 2 ft. The A-frame is 21 ft. high, and the boom is 35 ft. long. The machine will dump material 35 ft. from the center of the boat to center of dump; it will dig to 11 ft. below the surface of the water and dump 16 ft. above water level. The boiler is vertical, 48 ins. diameter and 90 ft. high, with a steam drum separator to enable the use of ditch water for steam purposes and prevent its carrying water over to the engines. The dipper is of ¾-yd. struck capacity, without teeth. The engines have two cylinders, 8 × 8 ins., and the engine bed is mounted on a framing of steel I-beams, which also carries the drums.

In order to reduce the work of the operator, and so enable him to run the machine at high capacity, the mechanism is so arranged that he has only two levers to handle. One lever operates the hoisting and backing drums and the throttle; the other operates the swinging movements only. The movements are said to give much greater facility of operation than those ordinarily employed in the handling of dredging machinery. The light effort required in using the hoisting lever enables the operator to use the same lever for the throttle with a sideways motion of his hand. He need never let go of the throttle lever while operating his machine, and this enables him to operate it much more safely and rapidly than where three levers are used for these three applications. There is also a foot lever connected to the backing friction, so that if he should have reason to throw in the hoist and backing motions at the same time he can do so by holding the hand hoisting lever and stepping lightly on the foot-backing lever. Fig. 2 shows the arrangement of the hand and foot levers.

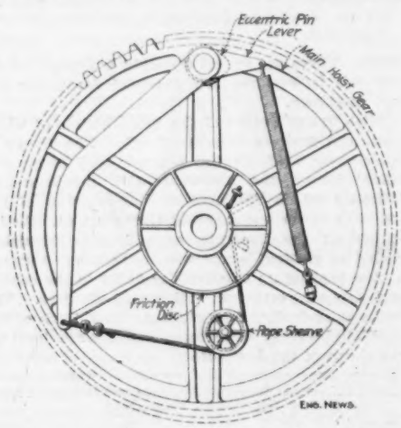


Fig. 3. Friction Clutch Gear of Ditching Dredge.

The friction clutches are of the band type, but are of new design, and are not put into engagement directly by the operating levers. Fig. 3 shows the clutch for the main hoisting gear. The rod from the lever is connected to a band on the small disk on the drum shaft; the movement of the hand lever retards the revolution of the disk so that it pulls on the cable leading to the end of the lever which sets the main band friction clutch. The frictions are positive in release and very sensitive, while they are so arranged on the drum head as to prevent sudden or excessive shock, thus reducing wear of the chain and other parts of the machinery. The dipper is secured to the dipper handle by heavy angles and plates, so that there are no braces to bend or pins to wear out.

Another new feature of the dredge is in the arrangement of the bank spuds and the machinery to operate them. The spuds are inclined, and are fitted with shoes, while braces extend from the hull to the feet of the spuds. There is a small independent reversing engine to operate the four drums, two for hoisting and two for setting or "pinning up." Steel cables lead from the hoisting drums and are reaved four times to the lower end of the spud. The cables from the setting-up drums are reaved eight times to the top end of the spud. Running the engine one way raises the spud, reversing it lowers and sets the spud. Where the spud feet are not buried it is possible to raise both spuds at once, and when the dredge is moved ahead to reverse the engine and shove the spuds down and pin them up without the swinging of the boom, as is necessary on many other dredges. The levers for this machinery are in easy reach of the dredge operator, and as the drums are held and driven by a worm screw there are no latches or dogs to trip and the operator can handle the spuds without additional help. He can raise or lower a spud at any time without changing his position and can pin the spud up without losing any time in the operation of the dipper. As such machines are to be operated day and night, stopping only for oiling, the makers have used special care in the design so that the operator having the throttle lever always in his hand when the machine is at work can stop the machine instantly to avoid accidents. Nearly every bearing is fitted with a cup for hard grease.

In regard to the work of the machine at Council Bluffs, we learn from Mr. S. L. Etnyre, City Engineer, that the length of dredged work on Indian Creek will be about 3¼ miles, with 100,000 cu. yds. of material. The width is 30 ft. at top and 10 ft. at bottom, with an average depth of cut of 8 ft. in the bed and 12 ft. at the sides. The material is black loam, with some gumbo, and the side slopes are about ½ to 1. In September the machine was excavating about 70 cu. yds. per day, at a cost of 4 cts. per yd. After this work is completed the machine may be put on rollers and used with a clamshell bucket to excavate two miles of channel up into the city, where the bridges are very numerous, so that a floating dredge cannot be used.

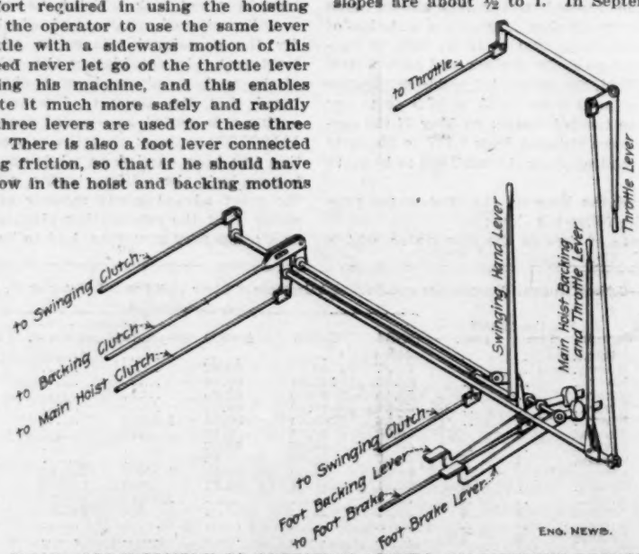


FIG. 2. ARRANGEMENT OF OPERATING LEVERS ON DITCHING DREDGE.

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The ideal of building structures in absolute correspondence to the conditions presupposed in their design has for some years back been the guiding light in the development of European masonry-arch construction. Following the experimental demonstration that masonry arches behave precisely as solid elastic structures, efforts were directed toward simplifying the structural system of the arch and eliminating as far as possible all sources of erratic stress. To change the loading from an indefinite one to one fairly definite in amount and distribution, the "free-ring" arch bridge was developed, in which the solid backing is replaced by separate piers carrying the roadway by means of small secondary arches. To render the structure as a whole statically determinate, by eliminating stresses due to temperature and to distortion under load, hinges were provided, usually at the two springing lines and at the crown. Finally, to make certain that the masonry rib would occupy its intended position precisely, without internal stresses and without being affected by unequal deformation of the centers, the practice developed of starting the setting of arch stones at many points of the arch simultaneously; the effect of this procedure was to make the deflection of the centering uniform, and to provide a number of virtual temporary hinge joints for simultaneous closure.

Some or all of these three expedients have been adopted in most of the large European masonry arch bridges built in recent years. In Germany, Italy and Austria it has become preferred design to use all three; indeed, the same expedients have repeatedly been applied to concrete and concrete-steel arches. In France the employment of hinges found less favor; we do not at this moment recall any large French masonry arch provided with hinges. But the other two expedients: the free-ring construction and subdivided erection, have been much used in France.

American designers of stone arches have as yet shown little inclination to adopt these European methods. The hinged masonry arch is unknown here, while free-ring construction and subdivided erection have been used very rarely. Yet there is a growing sentiment even in America that the three methods in question embody right principles and must be considered as forming part of the modern design of masonry arches. For this reason it is a matter of great interest to American engineers as well as to the European, that a large stone-arch bridge was wrecked during construction, in which these advanced methods were used in the design, and that the wreck would not have occurred had the old method of continuous construction been followed.

The fall of the Maximilian Bridge at Munich, fully described in another column, is attributed, by the technical expert employed to investigate it, to the use of an improper lubricant on the faces of the hinge joints. Stearin, according to experiments made by Professor Föppl, brings the friction coefficient of steel on steel down to 0.005, corresponding to an angularity of only 18' with the normal. Had the hinge surfaces been left untouched, the pressure line could have deviated over twenty times as much without harm. Also, if dowels had been used in the hinge faces, or if a pin hinge had been used, the sliding would have been impossible. But they were not used, not even in the crown hinge, where the mean pressure line made an angle of over 1° with the normal to the contact surface. The hinge design was unsatisfactory, even though similar hinges had been used on two other bridges at Munich and had given no trouble. Therefore, while in a hingeless arch of familiar type this particular accident could not have occurred, yet it would have been as surely prevented had *proper* hinges been used.

But a further fact bearing on this question must be considered here, a fact which is not recorded in our description of the failure, but which is given by Professor Dietz in his original article. It is to be remembered that the upper half shoes of the skewback hinges were not bolted or doweled to the masonry, but merely rested against the skewback course of the arch, with a thin sheet of lead interposed. While the arch ring was being constructed, being still on its centering, it was observed that numbers of these upper skewback shoes were slipping downward between the arch stones and the lower skewback shoes. In other words, there was not sufficient thrust against them to develop friction sufficient to hold them in place, although supposedly they were under a pressure corresponding to the thrust of so much of the arch as had already been erected. Indeed, since one of the two surfaces between which these shoes were sliding was composed of a sheet of lead in contact with planed cast iron, which surface would have a fairly high friction coefficient, it may be said that the shoes which slipped were quite loose and took no pressure whatever. If this occurred, it is evident that other hinges in the same horizontal line took a much greater pressure than belonged to them; the distribution of the total arch thrust among the 33 hinges of each joint must, therefore, have been quite irregular.

It would seem reasonable to assume that, if the hinge pressures were very irregularly distributed in a partially-erected arch, they would also be irregularly distributed in the finished arch, when the mortar in all joints had set and the arch ring had become a solid body. And if this be the case, then the hinged arch is subject to internal initial stresses just as much as the hingeless arch, so that a good share of the value of the more refined construction disappears. Professor Dietz states, it is true, that the hinge shoes which slipped thus were jacked back into place, requiring quite heavy pressure to move them; this would indicate that some pressure had come upon them subsequent to their slipping, and possibly that the irregularity of thrust distribution had partly adjusted itself. This is not conclusively shown, however.

The argument for using metal hinges in masonry arches does not find support in the history of the Maximilian Bridge. The most refined design and the most careful conduct of the construction work did not suffice to secure the intended distribution of thrust or to prevent an accident fatal to the structure. Further, this arch was intended to be made virtually continuous by concreting the hinge joints after completion. Is the temporary service of the hinges worth the additional complication they introduce? Is it not sufficient to secure definite central location of pressure line for unloaded arch by thoroughly carrying out the method of subdivided erection? French engineers quite generally have concluded that it is. The Gour Noir 200-ft. arch described in Engineering News of August 18, 1892, is an excellent illustration, and the dozen years since have not altered this condition. We are inclined to hold with the French engineers in their argument.

A gratifying feature of the Maximilian Bridge accident is the behavior of the arch masonry in the fall. It is reported that many of the face stones were cracked and spalled, but that the arch masonry as a whole showed little apparent injury. Considering that the arches dropped more than a foot at the end hinges, or about two-thirds of a foot at the centers of gravity, this presents itself as brilliant testimony to the solidity and efficiency of well-laid masonry.

"105 Miles an Hour Record for Central," was the headline which the New York "Times" this week placed over an item regarding a run from Albany to New York over the New York Central & Hudson River R. R. An examination of the item showed the actual facts to be as follows: The through mail train from the West left Albany at 1.45 a. m., Oct. 13, 1 hour and 10 minutes late and made the run to New York City, 143 miles, in 142 minutes, or at an average speed a little over 60 miles per hour. The record was taken *to the nearest minute only* of the time of passing each station, and taking these records in connection with the table of mileage between stations, the clever reporter figured out the rate of speed between stations as follows:

The 4.33 miles between Tivoli and Barrytown was made in exactly 3 minutes, or at the rate of 87 miles an hour. The run from Rhinecliff to Staatsburg, 5.49 miles, was made in 4 minutes, or at the rate of nearly 83 miles an hour, but these performances were eclipsed between Croton and Ossining, when Butterfield, pushing his engine to the limit, made the 3.51 miles in exactly 2 minutes, or at the tremendous rate of 105 miles an hour.

This all sounds very plausible to the newspaper reader and makes fine advertising for the passenger department; but as an actual speed record it of course will not stand examination. If instead of Croton and Ossining, we take Peekskill and Tarrytown, the stations next beyond Croton and Ossining, we have by the "Times" own figures a distance of 16.03 miles run in 15 minutes, or at the rate of 64.12 miles per hour, which is a very different speed from 105 miles.

It may be set down, in fact, that no railway speed record in excess of 75 miles per hour is deserving of credence unless the time is measured to seconds by stop watches in the hands of careful observers, or the locomotive is equipped, as American locomotives very rarely are, with an automatic speed recorder.

It may be added that all the circumstances point to the improbability of the attainment of any such speed as 105 miles per hour by the train in question over so crooked a road as the Hudson River Division.

One of the highest authenticated speed records ever made was on the Central R. R. of New Jersey on Nov. 18, 1892, when two miles near Fanwood, N. J., were passed over at the rate of 97.3 miles per hour, according to stop-watch measurement. This speed was attained in the middle of a very long tangent and where the engine was aided by a down grade for some distance, circumstances far more favorable to high speed than the conditions under which the New York Central's alleged speed record was made.

THE LATEST RAILWAY ACCIDENT STATISTICS OF THE INTERSTATE COMMERCE COMMISSION.

The statistics of railway train accidents for the year ending June 30, 1904, just issued by the Interstate Commerce Commission, show a record of fatalities and injuries never approached in any previous year. The final figures show a total of 3,787 passengers and employees killed outright, and 51,343 more or less seriously injured as a result of railway train accidents during the year. How very largely these figures exceed the record

of the two previous years is made clear by the accompanying Table I., reproduced from the Commission's report. It must be remembered, also, that even these enormous figures do not represent the total casualties due to railway operation, for the accidents to persons other than employees or passengers are not included. Thus persons killed at grade crossings or while walking on the track, tramps and others killed or injured while stealing rides on freight trains, or on passenger car trucks, and employees in railroad shops who suffer accident are not included at all in the above totals. Again these official statistics are collected only from railways engaged in interstate commerce, and thus accidents on nearly all electric and interurban railways are not included.

Statistics of accidents in the operation of electric and street railways are not obtainable; but the Interstate Commerce Commission does collect and publish in its annual report the casualties occurring on railways to persons other than employees and passengers. In the year ending June 30, 1902, these casualties amounted to the enormous number of 5,274 persons killed outright, and 7,455 injured. If we assume an equal number of casualties to "other" persons to have occurred in the fiscal year just closed, it would make the total casualties due to railway operation in the United States in the year ending June 30 last, over 9,000 persons killed outright and nearly 60,000 persons injured.

Surely, such a casualty record ought to arrest public attention and arouse inquiry. Nine thousand persons killed outright and sixty thousand wounded in a single year! Imagine the fearful total of carnage and suffering which these figures represent. Picture a catastrophe which visits a city of nine thousand population and kills every person in it, and then wounds or maims every person living in a city of sixty thousand population. It is a fact that the equivalent of such a catastrophe visits the United States every year.

Let us put the case in still more concrete form: Suppose that some superhuman power or some cataclysm of nature like the eruption at St. Pierre or the flood at Galveston were to descend upon the city of Camden, N. J., or Bridgeport, Conn., or Des Moines, Ia., were to kill outright one person in eight of the population and cripple or wound all the rest.

Suppose further that it should become known that every year thereafter some other city in the United States of similar size would receive a like terrible visitation. Who can portray the outburst of horror and dismay which would result throughout the civilized world?

Yet just such a record of death and suffering is being annually recorded, and because it is not one single large calamity, but is made up of a multitude of minor accidents, occurring all the time, daily and weekly, and scattered over all parts of the country, we grow calloused to it all and forget what it really represents.

But the most salient and important fact shown by these statistics of railway accidents is that they are increasing, and increasing, moreover, at an alarming rate. This is shown for the last three years by Table I., and in more detail by Table II. In this comparison the record of 1904 looks black indeed compared with that of 1902; but the unfortunate fact is that if we follow the records still further back we find that 1902 was a year of unprecedented casualties compared with previous years.

If we go no further back than 16 years we find by the Interstate Commerce Commission's statistics that in 1888 the total number of employees and passengers killed was only 2,385, with 22,288 injured. This was the record of casualty from all causes. In 1902 this had grown to 3,314 killed and 57,207 injured.

Here, then, we have a great increase in casualties from 1888 to 1902, and tables in the Interstate Commerce Commission's report show it to have been a fairly steady increase—and now 1904 shows a large increase in the casualties over 1902. Surely such a situation demands attention. Despite all that has been done in the introduction of safety appliances, such as automatic couplers, air brakes, block signals, interlocking plants, our progress according to these statistics is in a retrograde direction. We may well stop and seriously inquire what are the underlying reasons for our failure—for failure it certainly is.

The first reason assigned for the increase in accidents and the one of greatest importance, is the growth in traffic. There has been, of course, an enormous expansion in railway traffic in the past sixteen years, and something like a corresponding increase in total casualties is to be expected. The question comes, therefore, whether these two increases are actually proportionate. Are we killing and injuring more employees per million ton-

TABLE III.—Comparative Summary Showing Number of Employees, Trainmen and Passengers for One Killed and for One Injured in the United States, for the Years Ending June 30, 1902 to 1892.

Year.	Number of employees for one		Number of employees for one		Number of passengers for one	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
1902	401	24	135	10	1,883,706	97,244
1901	406	26	136	13	2,153,469	121,748
1900	399	26	137	11	2,316,648	139,740
1899	420	27	155	11	2,189,023	151,998
1898	447	28	150	11	2,267,270	170,141
1897	486	30	165	12	2,204,708	175,115
1896	444	28	152	10	2,827,474	178,132
1895	433	31	155	11	2,984,832	213 651
1894	428	33	156	12	1,668,791	178 210
1893	320	28	115	10	1,985,153	183,822
1892	322	29	113	10	1,491,910	173,833

miles of freight transportation produced or more passengers per million miles of passenger journeys now than we were five years or ten years or fifteen years ago? If we are not, then at least we are not retrograding; but if the ratio of casualties is actually increasing—if the railway employee or the passenger runs greater risk now than formerly, then, unquestionably, all our work in the introduction of safety appliances has not been sufficient to offset the causes which tend to increase the danger of railway transportation.

The only answer we are able to give to these queries is the figures in Table III., taken from the 1902 report of the Interstate Commerce Statistician. It will be seen from these figures that for the years 1892 to 1902 the casualty *rate* appears to have been about stationary. The apparent increase in the ratio of injuries is probably due chiefly to a more complete reporting of minor injuries in the later years.

But even if we assume that the casualty rate remained stationary in the years 1892 to 1902, it must be regretfully conceded from the showing of Table I. that it has increased during the past two years.

We all remember the reasons assigned for the heavy casualty records of 1902. Entirely plausible and probable, they certainly seemed to be. It was said that the enormous traffic which the railways carried in that year had not only given a greatly enlarged figure on which to base the casualty rate, but had so overtaxed the facilities of the railways that an excessive accident ratio was naturally to be expected. Moreover, the scarcity of labor had made it necessary to employ a poorer grade of men, and men of less experience in railway work.

But the congestion of traffic that prevailed in 1902 and 1903 has long since passed. The extra men who were procured from every possible source to help clear crowded yards and man extra freight trains have been laid off and gone to other occupations. It would have been entirely reasonable, therefore, to have predicted that 1904 would show an unprecedentedly low record of casualties, but here we find it surpassing the worst figures on record. What, we ask again, can be the underlying cause or conjunction of causes which are responsible for so disheartening a result?

We shall not attempt to answer this question in any authoritative way, and we doubt if any railway official anywhere in the country would be able to answer it with entire satisfaction. Something more than mere experience in a single department of railway work is needed to enable one to judge the relative importance of the causes which have operated to increase danger in the permanent way department and in the rolling stock department, for example. What seems entirely clear to us, however, is that the question ought to be answered and answered in some authoritative manner. The American Railway Association, for example, might well create a special committee to investigate the increased ratio of casualty in the railway service and its causes. It is the body best fitted by all odds to undertake this work, and if it does not undertake it, it is quite within the field of probabilities that the Government will step in with a commission to do it, and that the eventual result will be a considerable addition to the statutes relating to the compulsory introduction of railway safety appliances.

As we said above, we shall not attempt to make any dogmatic statement of the causes of increased danger in the railway service. We would present what follows merely as suggestions of the directions in which the sources of an increased accident ratio should be sought.

It seems probable that one cause of an increased accident ratio may be an increase in the average rate of train speeds. There are no statistics, it is true, to show that train speeds are higher now on the average than they were five or ten or fifteen years ago; but a general knowledge of the changes taking place in railway service makes it well nigh certain that the general tendency is toward increased train speeds. That danger of accident does increase with increased train speeds will generally be admitted. The damage done by either derailment or collision, when it occurs, should vary theoretically not directly as the speed but as the square of the speed, since the energy stored in the moving train varies as the square of its velocity. For this reason an increase of even a mile or two per hour in the average speed of trains might easily have a noticeable influence on the casualty ratio.

TABLE I.—Casualties to Passengers and Employees on United States Railways in the years ending June 30.

	1904.		1903.		1902.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Passengers:						
In train accidents	270	4,945	164	4,424	167	3,586
Other causes	159	3,132	157	2,549	136	2,503
Total	429	8,077	321	6,973	303	6,089
Employees:						
In train accidents	844	6,990	895	6,440	697	5,046
In coupling accidents	278	3,441	239	2,788	143	2,113
Overhead obstructions, etc	116	1,210	93	992	104	1,070
Falling from cars, etc	700	9,371	678	8,025	537	6,867
Other causes	1,429	22,254	1,314	20,759	1,035	18,615
Total	3,367	43,266	3,383	39,004	2,516	33,711
Total passengers and employees	3,787	51,343	3,694	45,977	2,819	39,800

TABLE II.—Casualties in Railway Collisions and Derailments in years ending June 30.

	1904.				1903.		1902.	
	Number.	Loss.	Persons killed.	Persons injured.	Number.	Loss.	Number.	Loss.
Collisions, rear	1,736	$1,683,020	195	1,931	.....	.....	.....	.....
Collisions, butting	928	1,696,425	280	2,728	.....	.....	.....	.....
Collisions, trains separating	1,024	491,666	25	412	.....	.....	.....	.....
Collisions, miscellaneous	2,748	1,319,807	130	2,012	.....	.....	.....	.....
Total	6,436	5,190,918	630	7,083	6,167	$5,615,746	5,042	$4,285,683
Derailments due to defect of roadway, etc	866	612,538	23	716	821	636,718	547	443,706
Derailments due to defect of equipment	2,297	1,953,392	60	630	1,841	1,582,335	1,699	1,295,299
Derailments due to negligence of trainmen, signalmen, etc	323	302,592	41	355	297	230,907	255	196,241
Derailments due to unforeseen obstruction, etc	396	432,417	122	416	277	317,456	239	546,478
Derailments due to malicious obstruction of track, etc	110	102,717	19	196	71	157,290	57	68,245
Derailments due to miscellaneous causes	913	818,503	103	848	1,169	1,136,535	926	874,753
Total	4,855	4,192,159	368	3,161	4,476	3,981,231	3,663	3,359,728
Total collisions and derailments	11,291	9,383,077	1,018	10,244	10,643	9,596,977	8,675	7,645,406

Doubtless the most important change of the past ten years in American railroading is the increase in the size of locomotives and weight of cars and trains. We cannot trace to this cause any increase in the accidents due to failure of track or bridges; but it is unquestionably true that these heavy locomotives and long trains are exceedingly destructive to freight rolling stock. To the damage which is thus caused, some part of the increase in train accidents may possibly be due. It is noteworthy that nearly three times as many derailments are caused by defects of rolling stock as are caused by defects of the track itself.

Turning to the increase in the number of collisions, it will be conceded, of course, that these are evidence of defects in either the personnel or the system of operation. It is to collisions rather than derailments, moreover, that the bulk of the casualties in train accidents are due. The figures show that both the number of collisions and the number of casualties caused by them are on the increase. In other words, what has been done in the extension of the block system has not offset the increased danger which accompanies increased traffic moved under the train order system. It is quite within the field of possibilities, too, that the average railway employee of the present day is less reliable and will make a greater number of errors than the average railway employee of 25 years ago. If this is the case, then it would explain why the train order system at the present day breaks down oftener and causes more accidents than it did with the employees of a quarter century ago, and would furnish a new argument for the introduction of block signals.

Whatever the causes of the increase in railroad accidents may be found to be, the lesson to be drawn is certainly that better men and better methods must be adopted. The increased accident ratio is due not to the introduction of safety appliances, but to the fact that their introduction has not gone forward fast enough or far enough. So where accidents are due to negligence of employees, the lesson is that discipline and training must be made more effective and better calculated to increase reliability. The value of an official inquiry by the American Railway Association, such as we have suggested, would be in pointing out the specific directions in which the introduction of better safety appliances and more effective discipline will produce the greatest results.

LETTERS TO THE EDITOR.

Proposed Water-Works and Sewerage for the City of Monterey, Mexico.

Sir: It may interest some of your readers to know that a valuable franchise has just been granted to Messrs. J. D. Stocker and William Walker, concessionaries of the Monterey Water and Sewerage Co., of Scranton, Pa. This concession gives the company the right to build and operate water-works and a sewerage system in the city of Monterey, Republic of Mexico, work to be commenced within three months of the delivery of the contract, and to be completed in three years. The franchise is regarded as a very valuable one, as it is backed by a government guarantee of 10% earnings on the cost of the work, but apart from the commercial side of the project, it offers several interesting engineering features.

The city of Monterey and the adjacent territory is underlaid at a shallow depth by a water-bearing stratum yielding a fair supply of water, such as it is, which may be pumped up into individual tanks and used under the consequent pressure for domestic and industrial purposes. It is, however, by no means a satisfactory source of supply, and after much exploration and study it has been decided to erect a dam in the canyon Santa Catarina, upon the river of the same name, in order to form a storage reservoir of sufficient capacity at a point distant some 8 or 9 miles from the city. A gravity pipe line is to connect the storage reservoir with a smaller distributing reservoir, near the city, from which the water will be delivered by gravity throughout the city.

The site of the dam is in a narrow gorge near the mouth of the canyon. Lofty peaks of heavy, compact blue limestone rise abruptly on both sides affording solid buttresses for the ends of the dam. Borings indicate that the hard rock lies some 55 or 60 ft. below the bed of the stream, overlaid by strata of varying character. The immediate surface is covered by vast deposits of shingle, forming the river bed, composed of water worn stones of all sizes, from the largest that can be carried by freshets down to coarse gravel.

The designing of the proposed dam and appurtenances was entrusted to the present writer. The dam will be about 350 ft. long and about 60 ft. high from the bed of the river to the level of the lip of the spillway. No practicable outlet was found for a natural overflow, and the surplus water will pass over the face of the dam.

A straight masonry dam of standard gravity section was decided upon as the best and most economical design for the given locality. Indispensably it must be carried down to solid rock, not only for security but also to cut off and utilize the underground flow through the water-bearing strata overlying the rock. Since the overflow water is to pass over the face of the dam, the loose material below will be protected from wash by a masonry apron extending a sufficient distance below the toe of the dam and terminated by a deep cut-off wall, to prevent undermining.

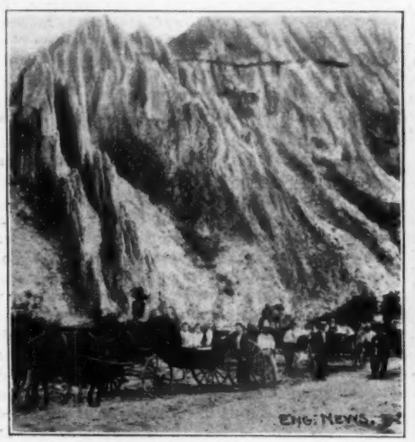
The dam is intended to be built of concrete, possibly with a double facing of rubble to avoid the expense of wooden forms in a country where lumber is very expensive. It is believed that the greater part of the stone for the concrete will be furnished by the shingle already mentioned. Sand of a very choice character can be found in considerable quantities in the river bed, but may be supplemented by crushing the natural rock if not sufficiently abundant.

The above brief description gives a general idea of this part of the proposed work, and indicates that the only constructional difficulty to be contended with will be excavating the foundation of the dam proper. It is believed, however, that this work, which may be carried on in any one of several different ways, will be favored greatly by the prolonged periods of drought or very light rains, and also by the fact that the freshets though reported to be heavy are of short duration, owing to small annual precipitation.

The inclosed photographs represent views of the Canyon Santa Catarina, where the proposed dam will be located.

E. Sherman Gould.

220 West 57th St., New York, Oct. 24, 1904.



VIEWS ON THE SANTA CATARINA RIVER NEAR MONTEREY, MEXICO.

The Failure of the Smith Avenue Bridge in St. Paul, Minn.

Sir. This accident, whereby part of an unloaded highway bridge is overturned by a tornado, as described by Mr. C. A. P. Turner in your issue of Sept. 1, is so rare that I think some further discussion may be of interest.

I wish first to correct a few errors in Mr. Turner's article, viz., that only one of the 250-ft. spans was overturned, making the total wreck to consist of the two 60-ft. plate girders, the 170-ft. shore span, and the first 250-ft. river span, two 2-leg bents and one 4-leg tower, all counted from the south abutment.

The secret of the wreck, I think, may rather be found in the imperfect anchorage of the 4-leg tower than in anything else.

Referring to Mr. Turner's article, the illustration Fig. 1 shows the two northerly pedestals for the overturned tower; the pedestal in the lower left-hand corner was the support of the fixed leg. This fixed support was provided with two 2½-in. anchor bolts, but without nuts. The threads of these bolts are not damaged beyond some scratches on the southwest side, caused by the movement of the soleplate.

The bridge was repainted last year, and as the threads are coated with paint the nuts have likely been away for a long time.

The other tower leg on the west side of the bridge was anchored by two 1¾-in. bolts.

Consequently the total anchorage on the windward side of the 4-leg tower, supporting one 170-ft. and one 250-ft. span, was only the two 1¾-in. bolts, which are broken under the nuts. The anchor bolts of the overturned 2-leg bents are also 1¾ ins. in diameter.

As the deck of the bridge was about 100 ft. above the top of the pedestals, and the width of the tower 55 ft. at the ground, it seems very reasonable that a strong wind would overcome the stability of such a comparatively light structure as this and the strength of two small anchor bolts, no matter how the laterals and connections between the spans were designed.

The general condition of the wrecked part of the bridge indicates also that the first part to give way was the 4-leg tower, which is thrown easterly nearly at right angle to the axis of the bridge. This movement has caused the 250-ft. span to break loose from its support on the remaining 2-leg bent at its northerly end (see Figs. 1 and 2 in Mr. Turner's article). The columns of the 2-leg bent at the southerly end of the 170-ft. span are provided with ½-in. sole plate, and the nuts on the anchor bolts on the windward side broke through this sole plate, tearing the edges of the holes. The 2-leg bent nearest the south abutment has fallen nearly parallel to the bridge, pulling the anchor bolts about 4½ ft. out of the westerly pedestal and bent them nearly semicircular in the direction of the bridge. This bent is evidently forced down by the weight of the falling bridge.

It is, of course, hard to determine whether the bridge would have been saved in case the nuts had been on the main anchor bolts (the two 2½-in. bolts) as the velocity of the wind is not known. The damage, however, done to the trees and brushes on the bank sloping directly down from the south abutment to the 4-leg tower is not very great, neither have the houses around the tower suffered so much as in some other parts of the city, where substantial structures were left undisturbed. The remaining part of the bridge is not damaged.

If not for the lacking nuts the bridge would very likely have been saved.

Yours truly,

R. A. Tanner.

Gilfillan Block, St. Paul, Minn., Oct. 1, 1904.

(A proof of the above letter was submitted to Mr. L. W. Rundlett, Commissioner of Public Works of St. Paul; in reply we have received the following letter, giving much additional information regarding this interesting bridge-wreck.—Ed.)

Sir. In my opinion Mr. Tanner has entirely failed to comprehend the character of the storm. His observations are erroneous and his conclusions not warranted by the existing facts.

I visited the bridge the next day after the storm, in company with Mr. Munster, chief engineer of the Chicago Great Western Ry., who was at the time the bridge was erected bridge engineer for the city of St. Paul, and was thoroughly familiar with every detail of the structure, and it was our opinion that the storm was cyclonic in its character and that the bridge was lifted from its position and not overturned by the power of a wind blowing in a horizontal direction. The following conditions were found:

The north end of the wrecked 250-ft. span rests on rollers on top of the rocking bent in the river. On the upstream or windward side some of the rollers are still in place; while on the down-stream side practically the whole roller nest is still intact. In the third panel of the railing on the part remaining, the sidewalk rail is bent in and the heavy gas pipe badly dented on the up-stream or windward side of the span. This shows that it must have been struck by some heavy object which must have been carried a long distance, and which was finally thrown outside of the cyclonic influence. The 250-ft. span lies in the river practically parallel to the line of the bridge, the north end of the span on the line of the axis of the bent. The south end of the 250-ft. span lies nearer to the center line of the bridge than the top of the tower posts.

The bottom ends of the two down-stream posts in the tower supporting the 250-ft. and 170-ft. spans were carried some distance down stream before striking the

ground, and although the anchor bolts are slightly bent, they failed by breaking in tension under the nuts. The position in which the tower posts fell shows a twisting action of the wind.

The condition of the roller beds on top of the rocking bent and the lay of the 250-ft. span in the river shows, in my opinion, that the 250-ft. span was lifted from its support, breaking the anchor bolt connection on the rocker bent simultaneously with the wrecking of the tower, which was also lifted from its pedestals, pulling the anchor-bolts apart. The position of the 250-ft. trusses with reference to the top of the posts shows the probability that the tower and also the 250-ft. span was lifted, breaking the shoe connection to the tower posts before or simultaneously with the wrecking of the tower.

If the failure of the bridge had been due to lack of anchorage on the up-stream posts in the tower bent supporting the 250-ft. span, as suggested by Mr. Tanner, the roller nests would undoubtedly have been carried down, and the position of the north end of the 250-ft. span would have been much closer to the center line of the bridge, and the down-stream posts in the tower would not have been carried away from the piers before striking ground.

The line of the cyclonic influence was sharply defined. The foliage along the sides of the bluff, a short distance from the tower, was hardly disturbed, while the limits on the other side did not extend beyond the 250-ft. span. The center of force was high above the water. At the time of the examination its course was plainly marked across the island below the bridge by the breaking off of the tops of the trees and stripping the leaves and branches. It evidently passed high over the bathhouses which were situated on the island, and crossing the river diagonally, struck the top of the bluff at the north end of the Wabasha Street bridge, which is about 90 ft. above the level of the river at this point and a mile below the High Bridge (Smith Ave. bridge). The two buildings on either side of the Wabasha Street bridge were wrecked, one being entirely destroyed and the other badly damaged, and here was where the only loss of life occurred. From this point the cyclonic action of the storm can be traced directly across the business district. Large buildings were unroofed, and chimneys and skylights blown away. The usual cyclonic freaks were apparent. In one instance the top story was taken out of a building, and the roof dropped upon the next floor, while little more than a block away a roof which was temporarily supported on jacks was left untouched. Through the residence district houses were destroyed or unroofed and one church entirely destroyed, a roundhouse overturned, and trees uprooted and pointing in every direction. That there was not more loss of life under these conditions is something of a marvel. The Government signal office, which was not in the line of the destruction, and entirely outside the belt of cyclonic action, showed a record of 180 miles an hour before the instrument broke. Taking all these matters into consideration, I think there is no question of the cyclonic nature of the storm, which, acting with terrific force on the 250-ft. span and tower bent, caused its destruction.

Just one word in regard to the character of the bridge. It was not a light structure, but on the contrary was built very heavily for a highway bridge, intended to carry street cars, fire engines and everything connected with street traffic, and was very thoroughly built, under competent inspection, and there is no doubt that every bolt, nut and rivet was in place and the bridge was in perfect adjustment, when completed. In 1899, a slight settlement was observed in the two pedestal piers on the river side of the tower span which was destroyed, and the shoes were wedged up to the proper level and Portland cement run under to give the proper bearing. I was not city engineer at the time this work was completed, and have no personal knowledge of how the work was left. I have been assured by the engineer in charge that the nuts were replaced. The bridge was painted in 1902, the work being finished after my return to office, but no report was ever made in regard to any missing bolts on any portion of the bridge. Some slight repairs have been made since that time and the bridge has been examined from time to time to see that everything was all right, and no report was ever made of the absence of any nuts, and I am entirely at a loss to know when they could have been taken off or why the fact was overlooked. As the piers are built considerably above the ground, their absence would not be noticed unless somebody had climbed upon the piers.

Yours very truly,

L. W. Rundlett,
Commissioner of Public Works.

St. Paul, Minn., Oct. 21, 1904.

Notes and Queries.

The sewage experiment station of the Massachusetts Institute of Technology, favorably mentioned on p. 350 of our issue of Oct. 20, was wrongly spoken of, in the opening sentence of our note, as pertaining to the Massachusetts State Board of Health. We regret the error, but after nearly fifteen years of frequent reference to the sewage experiment station of the Massachusetts State Board of Health, perhaps it is not surprising that the slip was made.

R. S. L., Sudbury, Ont., writes:

Could you give me any information as to whether any tests of concrete have been made to determine the effect upon the strength of the concrete of variations in the quality of the stone used?—i. e., for example, difference in strength of concrete of, say, trap, sandstone (hard and soft), slate, shale, etc.

A chain is no stronger than its weakest link, and concrete will evidently have its strength affected by the strength of the stones embedded in it, if these are weaker than the matrix of cement mortar in which they are embedded. In general slates and shales are unsuitable for concrete on account of the planes of weakness between the successive layers. Nevertheless, the margin of strength of concrete is often so greatly in excess of the loads imposed upon it that in case of necessity it can be made of very unpromising materials for the aggregate. On the other hand where great strength and solidity are requisite in concrete, a hard, firm rock with no planes of weakness, such as trap, granite, or some limestones and sandstones will give best results.

STEEL SHEET PILING FOR FOUNDATION CAISSONS.

The peculiarities of soil conditions in Chicago necessitate various special methods of constructing the foundations of the high and heavy buildings now becoming so general in that city. An interesting case is the application of steel sheet piling to form caissons for the foundation piers of the new warehouse for Marshall Field & Co., on the west side of the Chicago River at Polk St.

The building is to be founded on concrete piers extending to bed rock, and it was proposed to sink circular shafts with timber lining in accordance with the methods now in general use for such work. The piers were to be 90 to 100 ft. deep, penetrating blue clay, soft sliding clay, quicksand, silt and about 15 ft. of hardpan on top of the bed rock. The first 50 ft. of the depth was found very difficult to penetrate, owing to the soft swelling clay and quicksand. The first caisson was 7 ft. diameter, with a lining of wood staves braced by interior iron rings. At a depth of 30 ft. the clay and quicksand filled in as fast as it could be excavated, and work had to be stopped as the surface of Polk St. sank so much that the bridge had to be closed to traffic for a time. A circular shield of ½-in. steel plates, and with a sharp cutting edge, was then built, being assembled in four sections, with ledges for hydraulic jacks to force it down. This did not prove successful.

The use of steel sheet piling was then tried, using the Friestedt interlocking channel-bar piling, described in our issue of June 11, 1903. The piling was in 40 ft. lengths, and driven so as to form a caisson 5 ft. 2 ins. square. The length of 40 ft. was considered ample to pass through the soft strata, the ordinary method with the use of wood sheathing being then continued to the rock. Every alternate pile consists of a steel channel bar with a Z-bar riveted near each flange. The other piles are plain channels.

The piles were driven by a Vulcan steam pile hammer. A corner pile was first set in position, and fitted with a cap to take the blows of the hammer. The other piles were then driven until the caisson was completed. The weight of the hammer, about 5 tons, was sufficient to sink each pile about 25 or 30 ft., and then eight or ten blows sufficed to drive it to the required depth. There were eight caissons sunk in this way.

The contractors for the erection of the buildings are R. & S. Sollitt, of Chicago; and the steel piling was furnished by the Friestedt Interlocking Channel Bar Co., Tribune Building, Chicago.

TESTS OF LARGE METERS and other devices for measuring water for fire services were made at Lowell, Mass., on Oct. 5 and 6. For the following account of the tests we are indebted to Mr. R. J. Thomas, Superintendent of the Lowell Water-Works:

The following meters were tested for loss of pressure and for accuracy of registration: 6-in. Crest meter, manufactured by the Neptune Meter Co., of Newark, N. J.; 6-in. Union rotary meter of the Union Water Meter Co., of Worcester, Mass.; 6-in. Gem meter of the National Meter Co., of New York; 10-in. and 6-in. Torrent meters and 12-in. and 6-in. Giant meters, all manufactured by the Hersey Manufacturing Co., of South Boston, Mass. Besides the meters mentioned, two devices invented by Mr. J. A. Tilden, Manager of the Hersey Manufacturing Co., were also tested.

Tests for registration were made on orifices from 1-16-in. up to 4 ins. For loss of pressure 2, 3 and 4-in. streams were run. The equipment for testing consisted of a 6-in. pipe connected with the city mains, carried along one end of the engine room about 3 ft. above the floor and discharging through Freeman nozzles into the pump well. The loss of head was ascertained by means of a U-gage connected with piezometer rings on each end of the meter. A piezometer ring was also set on the Freeman nozzle, to which was connected a mercury column. The quantity of water delivered was figured on the nozzle discharge.

The closest registration was obtained from the Tilden devices, both of them registering about 100% on a 1-16-in. orifice. These devices are a combination of a 6-in. valve in the main line with a 3-in. meter on a by-pass. One known as the Tilden hydraulic valve has a regular 6-in. vertical disk valve, while the other has a 6-in. globe check valve. Delivering 2,500 gallons per minute through a 4-in. nozzle, the hydraulic valve showed a loss of head of 4½ lbs., against a loss of 29 lbs. through the globe check valve. The loss on the latter device, Mr. Tilden believes, can be cut down fully 50% by substituting for the 6-in. globe check an 8-in. globe check valve on a 6-in. swing check valve, either of which, no doubt, is quite practicable. The meters were tested both with and without a flash trap. Of the 6-in. meters, the Gem showed the least loss of pressure, which was 16 lbs., delivering 2,200 gallons per minute. Some of the other meters discharging the same quantity caused a loss of pressure as high as 41 lbs.

In the matter of registration the showing of the meters below ½-in. was unsatisfactory.

In connection with the test, diagrams and tables showing in detail the work of all the meters and devices were exhibited, all of which will be included in the report of the test to be published later by the Water Department of Lowell. The test was conducted by Mr. W. F. Sullivan of the City Engineer's office.

A WOOD WATER TANK AT UPPER SANDUSKY, O., burst about 10 p. m., Oct. 15. A number of near-by buildings were damaged to the total amount of some $1,500. The tank was built in or about 1888, and was supported on a brick tower 100 ft. in height.

The tank was 25 ft. high, 25 ft. in diameter at the bottom and 23 ft. at the top, and had a capacity of about 100,000 gallons. It was covered with a roof 4 ft. high. The staves were 3 ins. thick. The thickness of the steel hoops is not given, but it is said that their width was 4 ins. The failure is attributed to weakness of the hoops, due to corrosion, but it is stated that on June 30, 1904, the tank was inspected and pronounced safe by Mr. G. B. Finley, an engineer of Pittsburg, Pa., and that on Aug. 1 the tank was painted.

The practice was to fill the tank every night. Presumably this had been done the night of the failure. For the foregoing information we are indebted to Mr. Samuel J. Block, Superintendent of the Upper Sandusky Water-Works Co., Upper Sandusky, O.

SAND-LIME BRICK are now being manufactured by 50 separate concerns in the United States. According to the annual report of the U. S. Geological Survey on the "Clay Working Industries" the total capacity of these plants is about 1,000,000 bricks per day. According to the report the commercial development of the industry dates back only fifteen years in foreign countries and not more than four years in the United States. In 1896 Germany had only five factories where sand-lime brick was made, but now it has about 200, with an actual annual output of between 350,000,000 and 400,000,000. Early in 1901 a plant was built in Michigan City, Ind. In 1902 about 20 plants were in existence and 6,000,000 bricks were actually sold. Full and accurate data are not obtainable as to the actual output in 1903, but about 20,000,000 bricks have been reported as sold in that year. Many of the factories had just started and were not manufacturing to their full capacity during the year. A well-equipped sand-lime brick plant, with a capacity of from 16,000 to 20,000 bricks in ten to twelve hours, will cost, independent of site, from $20,000 to $25,000.

THE SIMPLON TUNNEL HEADINGS were advanced only 25m. (82 ft.) during the month of September. The north heading, it will be remembered, struck a heavy flow of water some months ago, and work continued in the south end of the tunnel only. On Sept. 6, 1904, the advance heading (bottom heading) of the south end struck a heavy blow of water at 115° F., which interrupted the work of drilling. A cross drift was then begun from the parallel heading (of tunnel II.) to the working point, to carry off the water. This drift was put through by the end of September, and work begun on timbering and lining it to carry the water without danger of falls, the rock being very seamy and broken hereabouts. Means were also taken to increase the supply of cooled air for reducing the temperature at the working face. The distance still remaining to be penetrated by the advance heading, on Oct. 1, was 244m (800 ft.). The quantity of water flowing from the south end of the tunnel at that time was 31 cu. ft. per sec., or about 20,000,000 gallons per day, measured at the portal.

A PHENOMENAL RIFLE SHOT RECORD AT MOVING targets was made by Mr. Chas. L. Baker, of Cox's Mills, near Richmond, Ind., recently. Wooden disks 3¼ ins. diameter and ¼-in. thick were thrown in the air at a distance of 25 ft. and were hit while in midair. Two thousand of these wooden targets were thrown into the air and successively hit by Baker. It was not expected that such a record would be made, and when the two-thousandths target had been hit, it was necessary to procure other targets. Green walnuts were substituted, and though they presented far more difficulties to the marksman than the 3¼-in. disks, Mr. Baker did not miss until the twenty-fifth walnut had been thrown in the air. The number of hits without a miss was, therefore, 2,024. The rifle used in the shooting was a Marlin .22 caliber, Model 1897, with 26-in. barrel.